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ABSTRACT

This monograph contains selected papers presented at the Second Special Session on Information Technologies, Productivity and Labour Market Implications, which took place at the Organisation for Economic Cooperation and Development on October 19-21, 1981. An introductory note summarizes significant points from the meeting. Part 1 contains a report that provides an analytical review of the findings and policies of national commission reports from 11 countries in the field of microelectronics-based technologies, with emphasis on productivity and employment. Following the report are selected replies and comments as well as statements by the Business and Industry Advisory Committee and the Trade Union Advisory Committee. The four papers in part 2 give an overview of the socioeconomic importance of the increasing application in manufacturing of microelectronics-supported machinery. Specific topics are trends in the production and use of industrial robots in West Germany; the promotion of robotics, computer-aided design, and computer-aided manufacturing in Sweden; robotization in Japanese industries; and the economic and social problems and effects of the change to robots. (YLB)

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INFORMATION COMPUTER COMMUNICATION POLICY



Micro-electronics,
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This report contains selected papers presented at the Second Special Session on Information Technologies, Productivity and Labour Market Implications, which took place at OECD Headquarters on 19th-21st October, 1981.

The meeting had two aims :

- To provide an analytical review of the findings and policies of National Commission Reports in the field of microelectronics-based technologies, with emphasis on productivity and employment (Part I).
- To provide an overview of the socio-economic importance of the increasing application in manufacturing of microelectronic-supported machinery, such as robots, numerically controlled machine tools, Computer-Aided Design and planning systems (Part II).

The views expressed in Parts I and II are those of the authors, and do not necessarily reflect those of the members of the Working Party on Information, Computer and Communications Policy, their governments or the OECD Secretariat.

The views of Member Governments are expressed in an introductory Note by the Committee for Scientific and Technological Policy on Technological Change and Employment. This Note was approved by the OECD Council on 25th October, 1982.

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NOTE BY
THE COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY
ON TECHNOLOGICAL CHANGE AND EMPLOYMENT

1. Currently there is renewed public concern that technological change and in particular the progress of automation and information technologies, the much-heralded "microelectronics revolution", may lead to increasing structural unemployment. The Committee for Scientific and Technological Policy therefore wishes to draw attention to the report by Paul Stoneman, Niklaus Blattner and Olivier Pastré which compares the findings of national commission reports from eleven countries dealing with the impact of microelectronics on employment.

2. This report was discussed at the Second Special Session of the Committee's Working Party on Information, Computer and Communications Policy held in October, 1981, on Information Technology, Productivity and Employment. The most significant points emerging from discussions at this meeting are summarised in the present note, and an attempt has been made to identify their policy implications. The Committee has, however, thought it useful to recall first a few general considerations on the relationship between technological change and employment.

Some General Considerations

3. It is, of course, impossible to predict with any certainty the total short-term or long-term effects of any technological development on the level of employment, especially as technology is only one of many variables involved. The Committee, however, wishes to recall that past experience, as well as economic theory, suggests that it may be easier to create employment opportunities when technological advance is rapid than when it is slow. While rapid technological change stimulates productivity, it also stimulates demand for goods and services by lowering their relative cost, by creating new goods and services and by spurring investment.

4. The decline in investment and productivity growth associated with the slow-down of the last years has made the unemployment problem more intractable. This problem

has been aggravated by a shift towards rationalisation and replacement investments. A significant acceleration of technological advance, and especially of radical new product innovation, could lead to increased investment and productivity growth and therefore contribute to economic recovery, thus making the unemployment problem easier to deal with. Unfortunately the climate is not favourable for making rapid progress in investment and innovation because of restrictive macro-economic policies, the general uncertainty prevailing throughout the world, the risks that are inherent in the innovation process itself and the rising costs of research and development. There is, thus, the risk of a vicious circle: without growth of economic activity, the investments on which the research and innovation system depends might not materialise; and without research and innovation, the growth of economic activity is liable to be compromised.

5. The impact of technological change on employment must also be viewed in connection with its role in international economic and trading relations. For a given country, rapid technological progress tends to be associated with the ability of domestic suppliers to compete with foreign firms on domestic and export markets. Such progress can help to combat inflation and balance-of-payments problems, and can be a key element in future adjustment to changing economic circumstances. In countries experiencing slower technological change, investment tends to be low, and exports to be in jeopardy; the growth of productivity is not sufficient to absorb significant wage increases without stimulating increases in costs and prices. This has significant consequences for employment in a context of general economic slow-down and recession.

6. However, even if aggregate demand and investment problems can be resolved, the 1980s may be marked by considerable adjustment problems as a result of the spread of microelectronics-based technologies. The Special Session of the Working Party on Information, Computer and Communications Policy was convened to illuminate the nature, extent and time dimensions of those adjustment problems. Discussions at this meeting highlighted a number of points which are summarised in the paragraphs below.

The impact of microelectronics-based technologies

7. In the last decade, developments in microelectronics-based technologies have opened prospects for the rapid evolution of equipment used in performing a great variety of tasks that involve receiving, processing transmitting and acting upon information. From an economic vantage point, the innovations in microelectronics-based technologies have three dimensions:

- miniaturisation;
- adding of "intelligence" to equipment;
- rapidly processing very large quantities of information at small cost.

As a consequence, microelectronics-based technologies can be introduced in any application that currently makes use of some information processing, from consumer goods to office equipment and manufacturing equipment. These technologies are not only of localised significance, but affect the economy in general.

8. Technological change induced by the increased diffusion of microelectronics-based technologies can considerably increase the productivity of the primary input factors - labour, capital and material resources. In manufacturing, such technologies include numerically controlled machines (in particular machine tools), industrial robots, computer-aided design and manufacturing, and flexible manufacturing techniques.

9. Labour productivity of many service sector occupations is being improved considerably by computer systems, word processors and other automated office equipment, and electronic-supported infrastructure systems like electronic mail. For the 80s the microelectronics-based technologies hold great promise for further increasing the productivity in the services, in particular through the possible "industrialisation" of services, i.e. the application to services of the systematic modes of analyses, design, organisation and control, common in the production process of manufacturing.

10. The application of microelectronics-based technologies may lower the cost of capital inputs while producing significant increases in productivity, because of the sharp reduction in the cost of these technologies combined with the versatility provided by micro-processors, which enables a single machine to perform various functions. Further cost savings and productivity gains may be achieved in other areas such as energy consumption and improved management of stock and resources.

11. The application of microelectronics-based technologies has led to productivity advances and thus strengthened the competitiveness of national economies. Although there have clearly been some job displacements, developments in microelectronics have not so far contributed to the current high levels of unemployment. Indeed, low levels of application of these new technologies in any individual country seem likely to lead to its economy becoming increasingly uncompetitive. This might result in serious adjustment problems in certain sectors, and have secondary effects on employment levels that could be far more serious than the direct displacement.

12. The impact of microelectronics-based technologies on any individual country will increasingly depend on their diffusion speed and pattern throughout the economy, which is conditioned by a number of factors, including:

- the industrial and commercial structure and relative size of the country;
- the technological position of the economy;
- the extent of the potential productivity gains to be derived from these technologies, and how they are distributed;
- the trading environment and the behaviour of other economies;
- the availability of trained manpower and management skills within the economy;
- social attitudes to technological change.

As a result of the large differences which exist between Member countries with regard to these factors, different views have been expressed on the appropriate diffusion speed of microelectronics-based technologies.

13. Concerns were expressed that microelectronics-based technologies will have a much more conspicuous impact on employment in the 80s. What gave rise to these concerns was the prospect that the structure of skill demands, and the industrial structure itself, will most probably be altered. This could seriously curtail job opportunities for young, unskilled workers, for the older and least mobile members of the workforce attached to traditional branches of commodity production and trade, and for females seeking employment without higher educational or skill qualifications. Concern was also expressed with regard to the impact of microelectronics-based technologies on working conditions.

14. While the application of these technologies might eliminate certain jobs and significantly change the content of others, it also up-grades the quality of some jobs and creates a substantial number of completely new occupations and employment opportunities. Many of these new jobs will require skills which are new or significantly higher than those of the jobs which might be eliminated. In fact, there appears to be a tendency for a shortage of some categories of qualified manpower such as software specialists in those countries where microelectronics-based technologies have been most developed.

15. It is difficult to forecast the overall effect of these technologies on employment because of uncertainties concerning the future strength of compensation effects at the macro-economic level, i.e. the extent that microelectronics-based technologies will lead to an increase in investment; how quickly and where disposable income resulting from their introduction will lead to the

creation of new jobs; and whether the improved price and quality of goods will lead to a timely and sufficient increase in demand.

Some policy implications

16. If the compensation effects continue to be strong, the aggregate demand for labour would not be affected to any great extent. However, government action may be needed not only to increase the speed of introduction and diffusion of these technologies, but also to make adaptation easier and less costly to the individuals concerned, for example by the participation of workers at an early stage of this process. Active manpower and training policies may facilitate the adaptation of the labour force to the introduction of the new technologies, while taking due account of social and cultural factors.

17. The Committee for Scientific and Technological Policy recognised that it cannot be predicted with any certainty whether the compensation effects will remain in the future as strong as they have been so far, and will be sufficient to offset the direct labour-saving effects of microelectronics-based technologies. One implication for science and technology policies is therefore the need to promote innovation in a much broader spectrum of technological areas than microelectronics and, in particular, to encourage actively new product and radical new process innovations that contribute most to obtaining higher general levels of growth, investment and employment.

18. It is clear from the above that the management of technological change and of its impacts on employment is influenced by policy decisions taken both at macro and micro level. This analysis illustrates a major conclusion of the March 1981 meeting of the Committee for Scientific and Technological Policy at Ministerial Level, that it is necessary to integrate policies for science and technology with other aspects of government policy, particularly economic, social, industrial, educational and manpower policies.

19. The Committee also wishes to stress that the above summary analysis should not be regarded as its final views on the relationship between technological change and employment, but rather as a progress report in a continuing effort to clarify the various issues involved. Considering the present economic and social situation and the pervasiveness of technological change, this effort is all the more urgent and the sharing of Member countries' experience in dealing with these issues must be pursued. In particular, such co-operation should aim at helping Member countries to better understand the role and relative influence of technological change in modifying the structure and nature of manufacturing and services, the

likely pace and pattern and conditions of the introduction of new technologies and their potential impacts on employment.

Part I

THE ECONOMIC AND SOCIAL IMPACT OF INFORMATION TECHNOLOGY

A. MAJOR FINDINGS AND POLICY RESPONSES TO
THE IMPACT OF INFORMATION TECHNOLOGIES
ON PRODUCTIVITY AND EMPLOYMENT

by

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INFORMATION TECHNOLOGY, PRODUCTIVITY AND EMPLOYMENT

INTRODUCTION

It is the purpose of this report to concentrate on (i) the findings and results and (ii) the policy recommendations and reactions elaborated in the reports of a number of Commissions created in OECD Member countries on the subject of Information Technology, Productivity and Employment. The intention is to identify and emphasize the size and scope of the structural changes in advanced economies resulting from the increased penetration of electronic based technologies.

The material for this report is based primarily on that presented in these National Commission reports(1), supplemented, where possible and time allowed, by other information available to the consultants. Given the heterogeneous nature of the reports and the limited time scale, we apologise for any omissions or misrepresentations (though we hope there are none). We must also point to some lack of quantification in the report. This lack of quantification, however, in many cases reflects a general opinion of many National Commissions that it is an almost impossible task to be definitive in quantitative terms about the matters under discussion, and it is therefore safer to resort to qualitative rather than quantitative conclusions.

It is as well to make clear at the start that we are concerned with the impact of microelectronics within individual nations. A world-based view may have some

1. Although the studies considered were mainly commissioned by government institutions, these institutions do not regard the reports as official in the sense of publicly recognised, definite knowledge but rather as a contribution to the still very open public discussion of the economic and social impact of the developments in field of microelectronics. A list of the reports discussed is included as Appendix II.

proponents, but we do not consider that to be our brief. We should also point out that we have taken as read that new technology can yield benefits to society and we have concentrated upon the costs of generating these benefits. This is not to belittle the nature of the benefits, it is just that most current discussion has centred on the costs.

1. THE GENERAL FRAMEWORK

Detailed descriptions of recent and expected future advances in information technology (primarily based on advances in microelectronics) can be found in most of the reports referred to in Appendix II. We do not intend to repeat the catalogue of advances here. We consider the advances to be of two basic types - process innovations and product innovations. While realising that one firm's new product may be another firm's new process and that new products often mean new processes and vice versa, the conceptual distinction is a useful one.

The presentation of this report is structured so that the effects of new technology in the 1970's are first discussed and then the forecasts for the 1980's are considered. The arguments presented in the National Commission Reports are detailed and analysed by imposing on the findings a fairly rigid formal categorisation. For example we consider the demand for labour in the aggregate and then by certain subcategories. We then consider supply. This structure is imposed to facilitate the presentation of our results but unfortunately suggests that the world can be neatly categorised. Of course the material in subsectors of our report is interdependent and should be considered as such. However by such categorisation we are able to not only separately consider impacts that are of interest in their own right but also to isolate the relative importance of different factors in an overall problem. This is best shown by example.

A primary concern of much of the discussion in this area is the impact that new technology has had or will have on unemployment. One can consider that unemployment will equal unfilled vacancies plus the difference

between aggregate labour supply and demand(1). Vacancies will arise for two basic reasons (a) because of an overall labour shortage or (b) because the type of labour the employer requires is not available on the labour market. We may thus argue that unemployment may arise because of "mismatches" in the labour market as well as because aggregate labour supply is greater than aggregate labour demand. In the report below we consider labour demand and supply in aggregate and by skill, geographical location, industrial location and age/sex composition. These latter considerations not only contribute to an understanding of where the impacts of new technology are likely to be most apparent, but as we have now shown are in fact vital elements in the understanding of the effects of new technology on aggregate unemployment.

It is to the effects of technology on the labour market that the first part of the report below is directed. This is then followed by a discussion of work conditions and the production process reflecting the concern that has been expressed over the impact of new technology on the "quality" of life. The third section of the report is concerned with the speed and extent of the diffusion of new information technology, for it is clear, especially from the first part of the report, that the impact of new technology will depend to a large extent on the diffusion process. Finally, we consider policy responses to the new technology and its repercussions before proceeding to our conclusions.

In the analysis below, especially that concerning labour market impacts, much of the discussion revolves around the extent to which the direct impacts of new technology will be offset by indirect effects. For example, it is generally argued that introducing new information technology will have the direct effect of enabling a unit of output to be produced by fewer workers, but whether this means that the demand for labour will also be lower will depend on whether the introduction of the new technology will indirectly affect output per man and/or output (either its level or composition). The indirect effects are generally labelled compensation effects. In Appendix I, we consider the "principle of compensation" on a theoretical and abstract level.

The results of the theoretical discussion can be summarised as follows. Possibilities do exist for

1. Labour supply (LS) will equal employment (E) plus unemployment (U) i.e. $LS = E + U$, and labour demand (LD) will equal employment plus unfilled vacancies (V) i.e. $LD = E + V$.
Thus $U = LS - E = V + LS - LD$.

direct labour saving to be offset by indirect increases in labour demands. Thus a simple aggregation of single sector, firm or industry case study - based estimates of direct labour effects will not yield a good overall estimate of the impact of new technology. The strength of the indirect impacts will depend inter alia on investment behaviour (which in turn will be related to the diffusion speed), success in foreign markets, the characteristics of the new technology, price and wage flexibility and the skill structure of the labour force. The time profile of the indirect impact will also be dependent on such factors. In particular it is worth noting that the degree of wage and price flexibility will be a key determinant of whether the impact of new technology falls on employment or real wages. It should also be noted that even if compensation effects do exist, there is every likelihood that any employment thereby created will not match the labour force released through direct effects either in skills or other characteristics. Moreover, any labour released directly may come not from the innovating firm, sector, or economy but from non-innovators. One cannot say, a priori, that the magnitude and timing of the compensation effects will always (or ever) be such as to yield equilibrium in the labour market at each moment in time. The question is how large will be the disequilibrium, and this is an empirical issue. It is to this issue that much of this report is directed.

Finally, before proceeding to the main body of the report it is worth noting that, among other factors the impact on any individual country is going to depend on its starting point. For example, if an economy is already heavily computerised, one might expect the impact of microelectronics to differ between countries. A purely agricultural economy may make large gains through terms of trade effects, whereas an economy with a large information sector may bear many costs from the new technology. We point this out to indicate that much of our discussion is general and not country specific. To give detailed commentary on each economy is beyond the scope of this analysis.

2. LABOUR MARKET EXPERIENCE IN THE 1970s

2.1. THE IMPACT ON LABOUR DEMAND

2.1.1. The aggregate

The factors affecting the aggregate level of employment in an economy are numerous and difficult to separate. A change in employment from one year to the next can be the result of government fiscal and monetary policy, world trading conditions, energy prices, exchange rate changes, exogenous shocks or technological change. Each individual factor would have direct and indirect effects and in many cases the outcome will be the result of numerous interactions. To say in such circumstances that technological change has thus led to X per cent of an economy's jobs disappearing is thus not only conceptually difficult but also infeasible. Thus New Zealand (p. 9) states a common opinion that "it is difficult to isolate the effects of microelectronics technology from the general economic structure". The Norwegian report presents a number of views as to why the recession of the 1970s occurred, varying from exogenous shocks, inflation fighting and technological reasons through to structural reasons and the industrialisation of LDC's. Despite the problems of isolating the effects of technological change at the macro-level, however, we must not rely too heavily on sectoral studies, for it is the nature of sectoral studies to ignore the wider reactions which can be picked up at a macro-level.

In Table 1 we present some estimates of increases in employment by country that show, if nothing else, that labour demand has in aggregate increased during the 1970s.

At the same time as these increases in employment have occurred, there have been considerable technological changes taking place. If we just consider computerisation, the data in Table 2 give some idea of the extent of the spread of computer use, although they underestimate the extent of this spread as they make no

Table 1
INDICES OF EMPLOYMENT 1970-1980

	1970	1975	1980	% increase 1970-1980
Canada	100	118.1	136.1	36.1
United States	100	107.8	123.6	23.6
Japan	100	102.5	107.3(a)	7.3(d)
Austria	100	111.2	116.1(a)	16.1(d)
Finland	100	104.5	100.7	0.7
Germany	100	94.8	95.4(a)	-4.6(d)
Italy	100	101.6	108.9(a)	8.9(d)
Norway	100(b)	103.5	116.0	16.0
Sweden	100	105.4	109.8	9.8
United Kingdom	100	100.9	99.9	-0.1
Australia	100	108.3	115.7	15.7
New Zealand	100	110.4	111.3(c)	11.3(d)

a) 1979.

b) 1972.

c) 1976.

d) % increase over period defined by dates of first and last observations.

Source: Adapted from ILO: Bulletin of Labour Statistics.

Table 2
NUMBER OF COMPUTERS INSTALLED 1970-1978

Countries	1970	1973	1978	% increase 1970-1978
United States	65,000	110,000	200,000	207
Western Europe	21,000	55,000	110,000	423
Japan	6,000	19,000	45,000	650
Others	18,000	46,000	95,000	428

Source: Rada, 1980, p. 52.

allowance for quality improvement. The message is however quite clear.

It is argued that major technological advances of the 1970s were electronic based. In Table 3 data on sales of semi-conductors and integrated circuits are detailed. These figures illustrate extensive advances in the use of the new electronic based technologies. What is interesting also is that the intensity of the application of microelectronics in the production of electronic apparatus differs quite significantly from country to country (Table 4).

Table 3
1976--79 SALES OF SEMICONDUCTORS AND
INTEGRATED CIRCUITS, WORLD TOTAL

Year	Semiconductors	Integrated Circuits
1976	6,635.1	3,491.0
1977	7,229.2	4,190.5
1978	8,267.5	5,008.8
1979	9,200.6	5,829.8

Figures in million U.S. Dollars.

Source: Rada (1980), p. 56.

Table 4

INTENSITY OF MICROELECTRONICS IN ELECTRONIC EQUIPMENT
Expenditure on Integrated Circuits as Percentage
of Equipment Sales in 1978

	Japan	United States	Europe
Data-Processing EDP	5.4	3.6	3.2
Telecommunications	4.2	2.4	1.3
Measurement and Control Instruments	4.1	1.8	1.9
Energy	0.6	1.0	0.5
Consumer Electronics	3.8	2.5	3.2
Domestic Appliances	0.7	0.7	0.2
Vehicle Electronics	0.3	2.8	0.4
Leisure Products	4.5	3.9	2.3
Total	3.3	2.4	1.7

Source: Siemens, in Anwendungen, Verbreitung und Auswirkungen der Mikroelektronik in Osterreich, p. 12.

These crude data suggest that although major advances in technology have been implemented in the world economy in the 1970s, these advances have not been directly associated with a decline in employment. We are not implying cause and effect here. However, in the aggregate the 1970s have shown increased employment (although as we will see below, also increased unemployment) along with the application of new technology. New technology and lower labour demand have not been obviously associated in the 1970s.

This is a view supported in several individual country studies. In France, Sarre (1980) considers that information technology had no direct impact on the demand for labour. This does not mean that there is no impact at all, for Pastré *et al* (1981) show that new information technology has changed the traditionally positive observed relationship between job creation and increases in capital intensity.

Turning to Austria, Germany and Switzerland, correlations between employment and labour productivity (as a proxy for technological change) shows that there is no clear relation between these two variables for the period under consideration. Although the data contained in Table 5 show a statistically positive correlation for the three countries under consideration in the 70s, the correlation coefficients are significant only for Switzerland.

On the basis of the evidence above, we suggest that at the aggregate level there is no reason to conclude that technological change and labour demand have been negatively correlated in the recent past.

2.1.2. By skill category

Studies of individual firms or industries are more prevalent than macro analyses, and it is by turning to these that we can get some idea of the past effect of technological change on the demand for labour by different skills. As is well known, however, it is notoriously difficult to define skills and we thus consider a number of possible concepts of skill. To the extent that skill is technology specific technological change is bound to lead to some displacement of old skills but also the creation of a demand for new skills. The results we will present tend to be derived from looking either at how sectoral occupational categories have changed over time, or how in individual case studies the demand for labour of different skills has changed. Of course the effect of technological progress on skill demand must really be seen relative to a counterfactual which is always by its nature hypothetical.

Table 5

THE CORRELATION BETWEEN THE RATES OF GROWTH OF LABOUR
PRODUCTIVITY (λ) AND EMPLOYMENT (ℓ) 1961-1979

	Austria		Germany		Switzerland	
	λ (1)	ℓ (2)	λ (3)	ℓ (4)	λ (5)	ℓ (6)
1961	3.7	1.8	3.7	1.3	3.3	4.7
1962	1.8	0.8	4.0	0.4	0.9	3.9
1963	4.1	0.1	2.7	0.2	3.4	1.5
1964	5.0	0.9	6.6	0.0	3.6	1.6
1965	2.2	0.7	5.0	0.5	3.9	-0.7
1966	5.4	0.2	2.8	-0.3	2.9	-0.4
1967	4.1	-1.1	3.2	-3.2	2.6	0.5
1968	5.4	-0.9	6.2	0.1	3.0	0.6
1969	5.5	0.8	6.2	1.5	3.8	1.7
1970	5.7	1.3	4.7	1.2	4.9	1.4
1971	2.5	2.7	3.0	0.2	2.7	1.4
1972	3.8	2.4	3.9	-0.3	2.5	0.7
1973	1.4	3.8	4.6	0.2	2.6	0.4
1974	2.4	1.9	2.4	-1.9	2.0	-0.5
1975	-1.5	0.0	1.6	-3.4	-2.2	-5.3
1976	5.0	1.1	6.1	-0.9	1.2	-3.3
1977	1.9	1.9	3.2	-0.2	2.2	0.2
1978	0.7	0.8	2.5	0.7	-0.4	0.6
1979	4.0	0.6	3.3	1.3	1.5	0.7

Correlation coefficients

1961-79	$r=0.237$	$r=0.397$	$r=0.533(*)$
1970-79	$r=0.114$	$r=0.397$	$r=0.732(*)$

*) Level of significance 0.02.

Sources:

1. Percentage rates of growth of GDP at 1970 prices per employed person [Source: Statistisches Handbuch für die Republik Oesterreich 1979, Wien, 1979, tables 5.10, p. 63 and 22.01, p. 301. Data 1979 see: Statistische Uebersichten, 54(6) 1981, pp. 1, 23].

2. Percentage rates of growth of employment [Sources: as under note (1), pp. 301 and 23].

3. Percentage rates of growth of GDP at 1970 prices per employed person (Source: Jahresgutachten 1980/81 des Sachverständigenrates, p. 252).

4. Percentage rates of growth of employment [Source: as under note (3), p. 240].

5. Percentage rates of growth of GDP at 1970 prices per employed person (Source: Blattner N., Mordasini B., Die Arbeitsproduktivität in der Schweiz 1960-1980: Entwicklung und Hypothesen der Erklärung, unpublished paper, September 1982, p. 55).

6. Percentage rates of growth of employment [Source: as under note (5), p. 27].

A failure to innovate may affect the demand for labour of different skills just as innovation will affect it.

Given these qualifications we can begin by looking at how the occupational structure of the labour force has changed over time. The data in Table 6 on Australia seems to be a fair representation of the pattern of changes in a number of countries, although we realise that any individual country has its own special characteristics.

Table 6

CHANGES IN THE OCCUPATIONAL STRUCTURE OF THE LABOUR
FORCE, AUSTRALIA 1967-1979

Occupation	% change in % share
Professional, Technical	+38
Admin., Exec & Managerial	+ 3
Clerical	+10
Sales	+ 9
Farmers	-23
Transport & Communication	-10
Service, Sport & Recreation	+14
Tradesmen, Production process workers, labourers & others	-13

Source: Myers Report, p. 94.

These figures show a move away from manual occupations towards managerial and professional groups. They reflect a trend towards higher average levels of skill and responsibility. They also reflect the trend over time, reflected in European experience, summarised as a growth in information handling occupations and a decline in assembling and craft skills [ETUI (1980)].

If we turn from the occupational structure and consider how the demand for labour with different educational levels has changed, the figures presented by the Dutch are informative. They illustrate that in the 1970/80 period the demand for labour of a low educational level fell by 23%, that for middle educational attainment rose by 21% and that for the highest educational level rose by 20%. This story is reflected in a number of reports. However, in the Norwegian report it is argued that a polarisation of the labour market has occurred. Four segments in the labour market are

defined - professional, skilled, unskilled and routine - and the polarisation is reflected in the fact that "the professional and routine job markets showed most of the growth in employment in the 1970s".

These aggregative results can be complemented by a number of disaggregated studies on the effect on skill requirements when microelectronics are introduced. The first obvious effect is an increase in demand for computer related skills as shown for example in France (Table 7).

The figures in Table 7, however, hide how different "information trades" have fared over time. Table 8 indicates how less skilled occupations have suffered relatively.

Table 7

BREAKDOWN OF INFORMATION SPECIALISTS
BY TYPE OF OCCUPATION IN FRANCE, 1979

Type of Occupation	Numbers employed (thousand)	
	1975	1979
Engineers and analysts	n.a.	29.9
Analyst-programmer and programmers	n.a.	40.0
Engineers and systems- programmers	n.a.	6.5
Operators	n.a.	77.6
Maintenance	n.a.	5.9
Technical salesmen and retailers	n.a.	7.5
TOTAL	120.0	167.4

Sources: Tebeka Report, 1980; Pastré et al, 1981.

Table 8

TRENDS IN THE RELATIVE SHARE IN ECONOMIC ACTIVITY
OF THE DIFFERENT INFORMATION OCCUPATIONS - FRANCE

(percentages)

Type of Occupation	1969	1970	1971	1972	1973	1974	1975
Analysts	7	8	10	11	11	12	12
Programmers	15	16	17	17	18	18	19
Computer and electro-mechanical machine operators	21	21	23	24	22	22	22
Calculating and electro-mechanical machine operators	22	20	17.5	16	18	17.5	19
Card-punch machine operators and verifiers	35	35	32.5	32	31	30.5	28
TOTAL	100	100	100	100	100	100	100

Source: Pastré et al, 1981.

If one looks at non-computer-related skills it is also observed that there is often a reduced demand for many of the less skilled jobs, e.g. routine clerical and filing jobs. In individual industries, e.g. printing, certain very skilled jobs relevant to the previous technology are also removed.

Peitchinis (1977) details a number of conclusions that arise from his case study approach to the effect of technological change on educational and skill requirements in Canada that seem to reflect many findings elsewhere at the case study level.

1. The occupations and skills of employees working with the new technology have been altered ... Some occupations are being eliminated and some being added.
2. On the average, technological changes have not had any significant effects on educational and skill requirement, but the aggregate hides some very significant variation amongst industries: whereas some industries indicated zero effect ... in other industries all workers required more or different kinds of both fundamental and technical knowledge.

3. There is evidence of some "de-skilling" effects of technological changes particularly in relation to specific job-related skills, acquired on-the-job.
4. Because most of the significant technological changes have been related to the introduction of electronics, their effects on education and skills appear to be greater on intermediate and high level personnel than on wage-earning occupations.

The unfortunate point about most case studies is that they concentrate on only one side of the new technology, e.g. production or use. The Japanese results presented in Table 9 try to look at both sides of this question and give a good overview of how new technology has different effects on different skills.

The overall impression from these results and the other commentary is that skill demands have been affected by the new technology, that the new jobs created require different skills from those destroyed and that on average the new jobs require higher levels of educational attainment than those destroyed.

2.1.3. By economic sector

As is evident from data in Table 10 the percentage of the labour force employed in different economic sectors has changed dramatically over time.

The points to note are the decline in the agricultural and industrial contribution to total employment and the increases in the information and services contribution. We shall say little about agriculture - for although there is and will be some use of microelectronics there, the effects are thought to be relatively small. The idea in this section is to see what evidence we can find for technological change displacing jobs in manufacturing, information and services in the past. Again we shall be dealing with effects mainly at the firm or industry level and as such not all direct and indirect effects will be catered for.

We first consider the information and service sector. In the proceedings of the first Special Session,

Table 9
EFFECTS OF NEW TECHNOLOGY ON DIFFERENT SKILLS, JAPAN

Manufacturers				Product	Users		
Devpt. Design	Manu- facturing	Sales/ Marketing	Parts Maker		Engineers	Skilled	Unskilled
+	o	+	-	Analytic Measuring	n.a.	-	n.a.
o	-	o	-	Process Control	-	-	n.a.
+	-	o	o	Manufacturing Automation	n.a.	-	-
+	-	+	n.a.	Ordinary Office Machines	n.a.	n.k.	n.k.
+	-	+	-	Commercial Machines	+	o	n.k.
o	-	o	o	Automatic Station Eqpt.	n.a.	n.a.	n.a.
+	-	o	n.a.	Watches, Calculators	n.a.	n.a.	n.a.
+	n.k.	n.k.	n.k.	Sewing Machines	n.a.	n.a.	n.a.

o = no effect
+ = increase

- = fall
n.a. = not applicable

n.k. = not known

Source: Microelectronics, Productivity and Employment ICCP Series No. 5, OECD,
Paris, 1981 (p. 168).

Table 10
SECTORAL DISTRIBUTION OF THE LABOUR FORCE

		% of economically active in			
		Information	Services	Industry	Agriculture
France	1954	20.3	24.1	36.9	24.7
	1975	32.1	28.1	29.9	9.9
Japan	1960	17.9	18.4	31.3	32.4
	1975	29.6	22.7	33.8	13.9
Sweden	1960	26.0	26.8	36.5	10.7
	1975	34.9	29.8	30.6	4.7
U.K.	1951	26.7	27.5	40.4	5.4
	1971	35.6	27.0	34.2	3.2
U.S.A.	1950	30.5	19.1	38.4	12.0
	1970	41.1	24.1	31.5	3.3
Germany	1950	18.3	20.9	38.3	22.5
	1978	33.2	25.9	35.1	5.8

Source: Information Activities, Electronics and
Telecommunications Technologies, ICCP Series, No. 6, Vol. I,
OECD, Paris, p. 29.

Table 11
EMPLOYMENT BY INDUSTRY DIVISION, 1950 and 1980 - UNITED STATES
(in thousands)

Industry Division(1)	1950		1980		Per cent
	Number of Employees	Percent of Total	Number of Employees	Percent of Total	Change in Employment 1950-1980
Total	45,197	100.0	90,657	100.0	100.6
Mining	901	2.0	1,025	1.1	13.8
Construction	2,364	5.2	4,469	4.9	89.0
Manufacturing	15,241	33.7	20,361	22.5	33.6
Transportation and Public Utilities	4,034	8.9	5,156	5.7	27.8
Wholesale and Retail Trade	9,386	20.8	20,573	22.7	119.2
Finance, Insurance and Real Estate	1,888	4.2	5,162	5.7	173.4
Services	5,357	11.9	17,741	19.6	231.2
Government	6,026	13.3	16,170	17.8	168.3

1. Excludes agriculture.
Source: Riche, 1980.

D. Kimbel(1) argues that "despite and/or because of the growing use of computers", there was considerable growth in employment in routine information handling activities between 1950 and 1976. Whether this is really the result of computer use is very difficult to say. However, Riche (1980) considers the impact of computers on clerical employment in the USA. He argues that in 1960 clerical workers numbered about 10 million (15 per cent of total employment). By 1980 computer use was extensive but clerical employment was 18 million (19 per cent of the total). This he attributes to normal growth in the volume of work and the extension of the scope of activities made possible by computers. Bennett (1981) in Australia(2) argues that increased demand for information in the Australian economy has led to the creation of approximately 20,000 jobs per annum, which just offsets the calculated potential job losses from computer use. In both cases therefore one has not observed that computer use has been associated with lower employment, although computers do lead to higher output per man.

Rada (1980) discusses the potential impact of word processors on employment in information handling, quoting results that word processors can increase typist productivity by 100 per cent or more (the IBM example showing a 148 per cent increase). His references to the research of APEX show that in certain cases this led to staff reductions. On this issue the Australian report has two illuminating statements(3): "it is impossible to allocate between the effects of office reorganisation, introduction of word processing and changed level of business" judging that "while there is clearly a net decline in typing/secretarial positions due to the introduction of word processing, job displacements of between three and five to one which have been claimed.... appear exaggerated, even after accounting for factors such as increased business". This latter view is also reflected in the United Kingdom report.

A major component of the information/service sector is banking and as a number of reports look at banking it is worth saying something on this. Rada points out that

1. See: Microelectronics, Productivity and Employment, OECD, ICCP Report No. 5, 1981, p. 18.

2. J. Bennet, Technological Change, Impact of Information Technology, 1981, p.60.

3. J. Bennet, op. cit., page 51.

in France by 1978 banks had already ceased to recruit(4) (going against a 5-10 per cent per annum trend growth to date), and that in the United Kingdom although business increased the banks reduced employment by 50,000 between 1970 and 1976. (This statement is contradicted in the United Kingdom report.) In Germany, jobs in the financial sector declined in 1976 although business was increasing. Given that the banking sector has been a major user of computer technology, the implied parallel is obvious. The Australian Commonwealth Banking Corporation state however that although computerisation could be said to "save" 8 per cent of their whole staff, "the range of the Corporations activities have changed so fundamentally since 1966 that the comparison is not realistic" (Myers Report, p.42). The banks claimed that the indirect effects exceeded any direct reduction effects(5). The bank unions feel that "one of the intended consequences of the computerisation to date was to reduce the staff requirements which otherwise would have been needed". This is our underlining and important. It does not seem unreasonable to argue that without electronic based technologies the banking services currently supplied could not be supplied or would be so costly that they would not be demanded.

We cannot leave the information sector without discussing telecommunication and télématique etc. Perhaps the most robust analysis is the Canadian investigation of the impact of technology on employment in Bell Telephones. Discussing (A) the introduction of direct distance dialling and (B) the introduction of modern switching equipment, they find that an increase in A from 53 per cent to 53 $\frac{1}{2}$ per cent usage results in a 0.25 per cent decrease in employment per unit of output produced, and an increase in B from 19.8 per cent to 20 per cent results in a 0.17 per cent decrease in labour demanded per unit of output produced, these aggregates however hiding changes within employment categories as well. It is worth noting, however, that the investigators find that of the total increase in total factor productivity only $\frac{1}{3}$ rd can be attributed to the diffusion of new technology. Rada stresses the manufacturing side of the telecommunication industry quoting how AT&T reduced its labour force from 39,000 to 19,000 between 1970/76 as the new electronic telephone systems were introduced.

4. Although it should be pointed out that others have argued that this could well be attributed to the halt that occurred around this time in the opening of new branches.

5. See also R. Elliott in Australia(2) pp. 169-197 for a restatement of this point.

Finally, we consider printing. In Germany between 1970 and 1976 the number of printers fell by 30 per cent, and in the United Kingdom the Times dispute is well documented. In Australia a decline in printing employment has been noticeable as are the de-skilling effects of new technology. Figures in the region of 20 per cent reduction in employment from computerisation are quoted.

To summarise on the information and services sector we may argue that microelectronics will reduce labour content per unit of output. But it also makes services cheaper to provide and there seems to be the possibility of increased demand to take up any labour released. We should not forget, however, that other factors may be of greater importance in determining labour demand. A report from the Alfred Marks Bureau in the United Kingdom showed that in the period since April 1979, 13 per cent of the reduction in the number of office jobs was due to the introduction of new technology (Computer Weekly, 20.8.81), i.e. 87 per cent of the reduction was due to other factors.

Turning to the manufacturing sector a recent survey of Canadian manufacturing firms by S. Peitchinis(6) suggests that:

1. the application of computer related technology has been the dominant form of innovation in Canadian manufacturing in recent years
2. the introduction of computers has not caused reduction in staff in the firms surveyed but has caused reductions in future staffing requirements.

Allied with this comment is the observation of jobless growth in manufacturing - output increases but jobs do not. Without investigating this phenomenon in detail except to state that it has been ascribed to technological change, we will turn to observations on individual industries.

It is perhaps appropriate to begin with the electronics industry. Rada details how despite considerable growth in sales the United Kingdom computer industry employed 43,000 in 1977 but 53,000 in 1971(7). Companies such as NCR (40 per cent), Olympia Werke (35 per cent), Olivetti (10 per cent) all experienced reductions in employment between 1969 and 1978, with the percentage

6. See Microelectronics, Productivity and Employment, OECD - ICCP Report No. 5, 1981, p. 193.

7. These figures are misleading. In 1970 employment was 49,000 and in 1972, 48,000.

of the labour force made up of blue collar workers decreasing even further. The United States computer industry increased employment by 1 per cent between 1976 and 1977 but sales rose by 12.9 per cent. In consumer electronics the introduction of integrated circuits and computerised assembly lines have had similar impacts. Norman (1980) details how seven Japanese colour TV manufacturers reduced their workforce by half between 1972 and 1976 while production increased by 25 per cent.

One must realise however that over the periods considered the computer industry (and the electronics industry in general) has considerably increased its bought-in inputs. To some extent employment is being shifted to component manufacturers.

The impact of the use of microelectronics on the cash register and watch industries do not really need retelling. The impact on the car industry is less well known. To date microelectronics has not had a great impact. The main advances are in car electrics, robot assembly lines etc. The main documented reports concern the removal of unpleasant jobs. Future impacts may be different.

The New Zealand report states:

"Responses from various groups closely associated with manufacturing show that there have been some job losses, mainly in the food industry Other firms, notably those who are new product and export oriented reported quite substantial job gains." (p.34).

Note that once again the indirect effects should not be ignored.

The studies undertaken by the Institute of Employment Research in the Federal Republic of Germany have to be mentioned here. Since 1970 this Institute has investigated the effects of technological change on employees in enterprises in different industries. Up to fifteen individual types of technological change have so far been distinguished in the research, ranging from the establishment of a new production unit to the substitution of one type of energy by another. Technological change connected with electronics is only one aspect of the whole field treated. The industries chosen were plastic-processing, woodworking, food, mechanical engineering, electrical engineering, steel, iron, tin, nonferrous products and printing and duplicating. It is

impossible to summarise the vast number of results satisfactorily here(8). One of the many noteworthy results is that enterprises displaying a rapid pace of technological change did not experience significantly higher outflows of personnel but they did experience an above average hiring rate. This finding is in accordance with another observation which is that in the case of technological change a higher proportion of the personnel required is sought outside the firm and not within the limits of the internal labour market.

These results are corroborated at the industry level. At this level a comparison of the R & D expenditures as a proportion of industry turnover with the development of industry employment in the Federal Republic of Germany for the period 1970-1977 shows that there is no evidence for R & D intensity being detrimental to employment (Germany, pp. 33 - 34).

Turning to Japan, we have a detailed study of the employment impact of the introduction of Numerically Controlled Machine Tools in a number of different industries Japan(9). At the date of the survey 47 per cent of the business establishments covered had introduced such machines. In both user and non-user establishments the number of regular employees decreased but by more (4.4 per cent compared to 2.5 per cent) in non using enterprises. Amongst users labour saving due to the use of NC machine tools etc. was a primary reason for reducing the size of the workforce (31.5 per cent), whereas an increase in the volume of orders received was the main reason for any increase in the workforce (68 per cent). Almost 30 per cent of users hired new employees to cope with new types of jobs resulting from the use of new technology. Overall the report states that the direct reduction in the number of employees was minimal.

Of course in the several country reports there is further detail and further case study data. But some summary is called for. We can argue that when microelectronics are introduced into existing products, then the direct labour requirements to produce those products decreases. When new microelectronics based processes are introduced then each unit of output requires less labour to produce. The overall effect however depends

1. For a description of the research see Dostal *et al.*, 1977 and Lahner *et al.* 1978. A brief survey is given in Dostal, 1981.

2. Research and Study concerning Influences on Microelectronics, Employment and Results of the Survey on Labour Statistics by Occupation in Fiscal Year 1980, Ministry of Labour, Foreign Press Centre, Japan, 1981.

on what happens to output. This is the case for both the manufacturing and information and services sectors.

In general, output will not advance at the same rate as productivity in all industries or plants, and consequently some industries will register employment gains while others register employment losses. The results of such effects are illustrated in Table 10. In Table 11 we present data on the industrial structure of employment in the United States. As can be seen in some industries, over the thirty year period, employment has hardly increased at all in others it has increased dramatically. Not all change of course is due to new technology. We can state however that the new jobs being created in this period were more likely to be outside manufacturing and in services, government and finance. What we will turn to later is whether this information sector can continue to increase employment opportunities in this manner.

2.1.4. By geographic region

There has been little research on this subject even though the majority of studies produced so far emphasise the potential of computerisation with regard to decentralisation. In France the distribution of information equipment and personnel throughout the economy tends to mirror disparities in development between regions. This inequality would seem to be all the greater if one considers only the most sophisticated equipment and the highest qualifications (Paris has 75 per cent of electronic engineers but only 51 per cent of programmers). Although these inequalities are tending to become a little less marked (in particular because of government policy aimed at achieving a more balanced geographic distribution of jobs), the very limited geographic mobility of jobs (in contrast to a very high level of occupation mobility within each region) does not suggest that a rapid decentralisation of information occupations will occur.

As far as enterprises in general are concerned, it does seem that some decentralisation has recently been achieved thanks to computerisation (transfer of factories or services to the provinces), but this has not meant any very marked decentralisation of powers (Nora and Minc, 1979).

These considerations do not reflect those geographical effects which may follow from a changing international division of labour which itself may well be connected with technological change. The case of the watch industry is a prime example. Although it is not

possible to explain the decline of this industry in Switzerland solely by the large-scale introduction of the electronic watch by competitors, electronic advance has certainly accelerated the decline. In Switzerland, watch making is heavily concentrated in a few locations. In some regions watch making accounted for up to a quarter of total employment in 1970. Since then, employment has more or less halved (Börsner 1978). It is also possible that microelectronic technological change is slowing down or even reversing the process of job transfer from the highly industrialised to the less developed countries for the new technologies may well be affecting the comparative cost position of the industrialised countries favourably.

2.1.5. By age and sex

One can argue that older workers tend to suffer from the deskilling effects of new technology and their lack of an appropriate educational background for re-training. At the other end of the age spectrum the problems arise from the fact that firms tend to reduce labour by natural wastage, the burden of job losses thus falls upon vacancies and new entrants to the labour markets have their job opportunities reduced. It is also argued that employment opportunities for women tend to be especially hard hit for they lack skills, often need to return to the labour market after a break to have children, are geographically immobile and tend to be employed in seemingly "high risk" industries and occupations. In all cases, however, although we see the logic of these arguments we have not found any convincing study analysing the effects in the past. However the Japanese study of NC machine tools shows how the old are under-represented in employment on NC machines relative to other metal working machines.

2.2. LABOUR SUPPLY IN THE 1970s

The supply curve of labour is usually taken as hours offered against the real wage with, in some theories, price expectations included. We cannot of course detail shifts in this curve over time. All we can really attempt to do is to make some general comments on how demographic and social factors have influenced the number of persons seeking jobs and fudge over the real wage problem. Moreover it may be difficult to get at reliable data on labour supply for in many cases (especially with married women) supply is hidden.

Norway details an increase in employment 1972/79 of 223,000, 140,000 of this total being married women, with the percentage of women in the labour force rising from 48 per cent to 58 per cent. However the total number of man-hours performed did not increase proportionately because of longer vacations, shorter working weeks and an increase in part-time jobs. In fact between 1972 and 1978, two thirds of the increase in employment came in the form of part-time working. The increase in female participation is an international phenomenon(10) and the increase in female part-time work has parallels elsewhere. The shorter working week is also noticed elsewhere, and is reflected in Table 12.

The Norwegian report also emphasised how the 1970s were the decade when the educational explosion made a definite impact on the labour market. An opinion also expressed elsewhere.

In Table 12 we present some details on the growth of labour supply in different countries(11). These figures(12), in combination with the comments above illustrate that in the 1970s, not only were there considerable differences between countries and thus the job creation requirements for full employment differed considerably between countries, but also in general:

- a) the labour supply was growing
- b) hours of work were falling
- c) the number of women in the labour force was increasing
- d) part-time work was spreading
- e) the educational level of the labour force was rising

For present purposes we have taken these trends to be independent of the process of technological change, but this need not necessarily be the case.

2.3. THE BALANCE OF SUPPLY AND DEMAND

By looking at the balance of supply and demand we hope to gain some insight into the impact that new

10. See ICCP Series, No. 6, OECD, *op. cit.*

11. These figures are derived from unemployment statistics, which of course involves certain biases, but they are good enough for our purposes.

12. Comparable figures for France were not available. Approximate growth of 40,000 p.a. (1975-80) in the labour force are indicated from other sources.

Table 12
LABOUR SUPPLY IN THE 1970s

Country	Increase 1970-80 %	Labour Force			Non-agricultural hours of work per week	
		1970	1975 '000s	1980	1970	1980
Canada	37.8	8,390	10,101	11,560	-	-
United States	25.7	83,428	92,117	104,901	37.1	35.3
Japan	13.3	49,166	52,632	55,714(a)	43.1	40.7(a)
Austria	14.8	2,435	2,773	2,797	-	-
Finland	7.3	2,150	2,318	2,315	-	-
Germany	8.4	21,264	22,856	23,055(a)	44.0	41.9(a)
Italy(d)	15.8	19,031	19,818	22,052(a)	7.8(b)	7.75(b)
Netherlands	1.3	4,218	3,906	4,276	44.4	41.3(a)
Norway	10.6	1,557	1,504	1,722	-	-
Sweden	9.3	3,933	4,187	4,300	38.2	35.6
United Kingdom	3.0	23,547	23,843	24,252	45.7(c)	44.0(a,c)
Australia	22.5	5,329	6,173	6,527(a)	-?527(a)	39.0

a) 1979.

b) per day.

c) male employees only.

d) change of base in 1977.

Source: ILO, Bulletin of Labour Statistics.

technology has had on unemployment. From the two sections above we can draw some conclusions as to how microelectronics may have separately affected demand and supply in the labour market, but we must note the general expressed opinion that the impact of technical change on the labour market may be outweighed by other effects. In general we can say that in the 1970s technical change led to different skill demands, is now taking place at a time of high unemployment, seems to have had little direct regional impact (although one must not forget the indirect effect through the international division of labour discussed above) but may affect the young, the old, and women particularly. The labour force has been growing in most countries, has higher educational levels, contains more women and more part-time workers.

In Table 13 we present data on unemployment in twelve countries that in general show higher unemployment in the late 1970s than the early 1970s. The unemployment figures can be disaggregated by age and skills. The pattern in the United Kingdom shows how the old are more likely to find difficulty in obtaining new jobs (Table 14). The focus of interest here is how are these unemployment figures related to the use of new technology.

As we have stated above unemployment can result from technological innovation, (assuming a given labour supply) either because of an overall reduction in labour demand or because the pattern of characteristics being demanded in terms of skills or industrial or geographical location do not match those currently available in the supply of labour.

If we first look at skills we have argued that the introduction of new technology has led to a change in the pattern of demand for skills. The size of the effect that this has on unemployment is difficult to estimate. If we consider United Kingdom unemployment data for 1980 we find that for computer related skills there is higher demand than for other types of skills e.g. the ratio of vacancies to unemployment for electronic engineers is 0.874, for programmers 0.190, but for clerks it is 0.129 and for general labourers 0.011. This suggests for example that if some of the unskilled had computer related skills there would be more chance of their being employed. However the total effect of this on unemployment cannot really be quantified. The Dutch report Table 3.9 p. 61 suggests that there are excess supplies of the most highly educated people, this does not, however, conflict with these figures above for there is no necessary one-to-one relationship between educational levels and skills.

Table 13
UNEMPLOYMENT 1970-1980

	Percentages										
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Canada	5.9	6.4	5.6	5.4	6.9	7.1	8.1	8.1	8.4	7.5	7.5
United States	4.9	5.9	5.6	4.9	5.6	8.5	7.8	7.8	6.0	5.8	7.1
Japan	1.2	1.2	1.4	1.3	1.4	1.9	2.0	2.0	2.2	2.1	-
Austria	2.4	2.1	1.9	1.6	1.5	2.0	2.0	1.8	2.1	2.8	1.9
Finland	1.9	2.3	2.5	2.3	1.7	2.2	4.0	6.1	7.5	6.1	4.8
Germany	0.7	0.8	1.1	1.2	2.6	4.7	4.6	4.5	4.3	3.8	-
Italy(a)	3.2	3.2	3.7	3.5	2.9	3.3	3.7	7.2	7.2	7.7	-
Netherlands	1.1	1.6	2.7	2.8	3.5	5.0	5.3	5.1	5.0	5.0	5.8
Norway	0.8	0.8	1.0	0.8	0.7	1.3	1.3	1.1	1.3	1.4	-
Sweden	1.5	2.5	2.7	2.5	2.0	1.6	1.6	1.8	2.2	2.1	2.0
United Kingdom	2.6	3.5	3.8	2.7	2.6	4.1	5.7	6.2	6.1	5.7	7.4
Australia	1.7	1.9	2.6	2.3	2.7	4.9	4.8	5.7	6.3	6.2	-

a) Change of series 1976/77.

Source: ILO Bulletin of Labour Statistics.

Table 14
UNEMPLOYMENT BY AGE - JANUARY 1981 - GREAT BRITAIN - MALES

Row	Under 18	18	19	20-24	25-29	30-34	35-44	45-49	50-54	55-59	60-64	65+	All
1. % of total unemployed falling in each age group	6.3	3.9	4.3	17.9	12.3	10.3	14.2	6.2	6.3	7.4	10.8	0.2	
2. % of unemployed with duration of 1 week or less falling in each age group (proxy for inflow)	11.0	5.0	4.6	18.9	12.9	11.2	14.4	5.6	5.3	5.3	5.7	5.05	
3. Ratio of rows 2 to 1. (Index of "inflow skewness")	1.75	1.30	1.08	1.06	1.05	1.09	1.01	.91	.86	.72	.52	.28	
4. Estimated "expected duration" (total $\frac{2}{3}$ < 1 week duration) (in weeks)	20.4	27.4	32.9	33.7	33.9	32.8	35.1	39.2	41.4	49.1	67.9	126.7	35.6
5. "expected duration" index (row 4 $\frac{2}{3}$ fig. for "all"). = inverse of row 3	.57	.77	.92	.95	.95	.92	.99	1.10	1.16	1.38	1.91	3.56	
6. Estimated avg. month "outflow probability" ($13/3 \frac{2}{3}$ row 4)	.21	.16	.13	.13	.13	.13	.12	.11	.10	.09	.06	.03	.12
7. % of age group with uncompleted duration over 52 weeks	1.9	4.7	11.4	13.9	16.4	18.0	21.2	26.0	30.2	32.6	39.3	64.8	20.5
8. "long duration" index (Row 7 $\frac{2}{3}$ fig. for "all")	.09	.23	.56	.68	.80	.88	1.04	1.27	1.47	1.59	1.92	3.16	

Calculated from: Department of Employment Gazette, February 1981, Table 2.6.

Turn now to the aggregate. The impact of technological change on unemployment is illustrated by the correlation between 1) labour productivity and employment growth and 2) labour productivity growth and the growth of potential labour supply. Unemployment will be lower if the first correlation is positive and if the second is negative.

While there is some, admittedly, weak support for the first correlation being positive (see Table 5), the results for Germany, (Table 15) indicate that the correlation coefficient calculated between the growth of labour supply and labour productivity is not negative, but positive (though very low, and not statistically significant). Similar correlation calculations for Austria generated negative but not significant estimates.

To investigate these correlations further, in Table 16 we re-present figures on labour supply, with figures on employment (70-78) and productivity growth (70-78) for different countries. We ought to point out, however, that the 70-78 period, contains an initial period of high productivity growth followed by a later period of low productivity growth in most countries. This should not, however, affect any conclusions we may draw.

The difference between the first two columns gives some idea of the disequilibrium in the labour market. Although we do not wish to imply cause and effect the following correlations are worth noting. (Parallels with Kendrick's observations are obvious⁽¹³⁾).

- a) High rates of growth of labour supply are associated with high rates of growth of employment in general.
- b) High rates of output growth can be associated with high (Canada) or low (Italy) rates of measured unemployment growth.
- c) High rates of productivity growth and thus by implication changes in technology seem to be associated with high rates of output growth (Italy and Japan) whereas low rates of productivity growth may be associated with low (Australia) or high (Canada and United States) rates of output growth.
- d) High rates of employment growth (Canada, United States, Austria) are associated with lower rates of productivity growth, and low rates of employment growth (Germany, Italy, Japan) are associated with high rates of productivity growth. However the same level of productivity growth

13. ICCP Series No. 5, OECD, op. cit, pp. 25-37.

Table 15

THE CORRELATION BETWEEN THE RATES OF GROWTH OF LABOUR
PRODUCTIVITY (λ) AND THE POTENTIAL LABOUR SUPPLY (l) IN THE
FEDERAL REPUBLIC OF GERMANY 1961-1979

	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
λ (1)	3.7	4.0	2.7	6.6	5.0	2.8	3.2	6.2	6.2	4.7	3.0	3.9	4.6	2.4	1.6	6.1	3.2	2.5	3.3
l (2)	0.8	0.3	0.3	0.0	0.5	-0.1	-1.3	-0.9	0.5	1.1	0.7	0.2	0.4	-0.5	-0.5	-0.6	-0.1	0.5	0.7
Correlation coefficient						1961-79					0.003								
						1970-79					0.108								

Sources: 1) Table 5.

2) Jahresgutachten 1980/81 des Sachverständigenrates, p. 61.

can be associated with very different employment growth (compare Austria and the United Kingdom).

Above, two important correlations were isolated, those between labour productivity growth and employment growth and between labour productivity growth and labour supply growth.

In the data in Table 16, both correlations are negative, the calculated value of the first being 0.46 and the second 0.28. These results suggest that there is no clear relationship between productivity growth and unemployment.

One might ask oneself however, whether such analysis really tells us much about the impact of new technology. To see whether a specific new technology, in this case microelectronics, causes unemployment we must really look at some counter-factual time path for the economy - that time path that would have been followed if the new technology had not been used. We can reason that on this counterfactual path productivity would have been lower, but by how much we cannot say. The effect on employment depends on whether or not the counter-factual path output would have been higher or lower. We thus have the compensation effects detailed elsewhere to consider. We have argued that these effects are not necessarily all positive or positive at all moments in time or for all circumstances, thus whether they mean higher or lower output relative to the counterfactual cannot be stated a priori. We have seen that in the past employment has increased and new technology has also been introduced. This does not however tell us whether employment would have increased faster (and thus current unemployment be lower) if new technology had not been introduced. All we can really say here is that we have found no evidence to contradict the implicit or explicit view of the majority of the National Commission reports that "technological changes in the past have not led to such unemployment" [Ireland, Vol. I p. 70].

A variation on the unemployment technology question is whether the unemployment of the 1970s was the result of the introduction of new technology. We have argued above that it is in fact the result of many factors (including the growth of labour supply) of which technology may be one. But on this point, in 1977, an OECD expert meeting addressing itself to the "Structural Determinants of Employment and Unemployment" led R. Leroy to the following conclusion with respect of the question of whether the unemployment in the second half of the 70s was caused by a wave of technological change:

Table 16

GROWTH IN LABOUR SUPPLY, EMPLOYMENT AND PRODUCTIVITY

Country	% Lab. Supply Growth 1970-80 [1]	% Empl. Growth 1970-78 [2]	% Output Growth 1970-78 [3]	% Prod. Growth 1970-78 [3 - 2]
Canada	37.8	27.4	41.7	14.3
United States	25.7	20.0	30.3	10.3
Japan	13.3	6.2	52.6	46.4
Austria	14.8	15.4	34.9	19.5
Finland	7.3	-1.6	24.3	25.9
Germany	8.4	-5.7	24.4	30.1
Italy(a)	15.8	2.3	40.3	38.0
Sweden	9.3	6.8	11.0	4.2
United Kingdom	3.0	1.0	20.0	19.0
Australia(a)	22.5	11.1	23.5	12.4

a) Cols. 2-4 based on 1970-77.

Sources: Col. [1] as Table 12.

Col. [2] ILO, Bulletin of Labour Statistics.

Col. [3] Rate of growth of GDP at constant prices. From United Nations Yearbook of National Account Statistics 1979, Vol. II, Table 9.

"The predominant answer is frankly negative, for the two reasons highlighted by consideration of the factors on which production depends. First, technical progress is stubbornly complex: major innovations spread and produce their effects through complex time channels, and besides the important discoveries there are a thousand innovations which are difficult to identify but which may have just as great an effect. Secondly, the implementation of technical progress is governed by economic conditions of profitability; what we observe in real economic life is not the result of pure technology but rather of the implementation of many-faced technical possibilities under conditions of fluctuating profitability." [Leroy (1977)]

This conclusion seems to be acceptable to the greatest number of experts for the second half of the 70s, but there is an expectation that technological change, especially that kind of change which is based on microelectronics, will possibly be able to exert a much more conspicuous role in the eighties than ever before, and it is to the consideration of this that we now turn.

3. EMPLOYMENT PROSPECTS IN THE 1980s

3.1. LABOUR DEMAND

3.1.1. The aggregate

Although electronic based technologies have been influencing economic conditions for many years micro-electronics, especially, is regarded as still being only at the beginning of wider-ranging developments. This is made especially clear in data taken from the Austrian study which shows two things: not only is the output of electronic apparatus expected to grow considerably between 1978 and 1985 (Table 17) but the market especially for integrated circuits, is expected to grow even more rapidly as the content of these elements in electronic apparatus rises (Tables 18 and 19). These predictions on growth rates should, however be considered in the context of what we have to say below about diffusion. It will suffice for present purposes however if we state that considerable growth in the use of microelectronics is predicted.

Given this prediction, we turn to consider its implications. It is in fact the case that prediction of future effects is in some ways simpler than trying to isolate past effects for one can conceptually hold other things constant. However the fact that the world develops in unexpected ways also makes the margin of error quite high. It is in the nature of many of these reports that they refuse to quantify or to make precise estimates of the employment effects of the new technology. In a number of places we found, however, the results of simulation exercises on macroeconomic models which we present below. The results from these models, it should be realised, are only as good as the model and its associated data inputs but they do tell us some useful stories.

We start with the model discussed in the Rathenau report. The model is described as an 150 equation clay-clay vintage model exhibiting, to date, Harrod neutral technical progress. The important export equation assumes that exports are related to the volume of world

Table 17

PRODUCTION OF ELECTRONIC EQUIPMENT IN 1978 and 1985

(Current prices in DM)

	Germany		Europe		United States		Japan		Western World	
	1978	1985	1978	1985	1978	1985	1978	1985	1978	1985
Data Processing EDP	7"7	17"0	22"0	49"7	50"0	83"0	14"0	35"5	87"0	174"2
Telecommunications	7"7	14"0	34"0	59"5	41"0	62"0	8"5	16"0	86"7	148"5
Measurement and Control Instruments	7"9	13"0	17"6	30"0	32"0	47"8	4"9	8"4	55"5	89"2
Energy	2"6	3"6	6"6	10"0	7"4	11"0	3"2	5"0	19"4	29"5
Consumer Electronics	7"9	9"0	20"6	33"0	12"0	14"0	16"2	29"0	63"2	103"0
Domestic Appliances	9"8	12"0	24"0	40"0	22"4	28"0	11"0	15"0	62"0	90"1
Vehicle Electronics	3"9	4"7	9"8	17"0	9"0	14"0	6"6	10"0	26"0	43"0
Leisure Products	1"2	1"7	3"2	6"0	6"4	11"0	8"8	16"5	21"4	41"0
TOTAL (market share in %)	48"7 (11.6)	75"0 (10.4)	137"8 (32.7)	245"2 (34.1)	180"2 (42.8)	270"8 (37.7)	73"2 (17.4)	135"4 (18.8)	421"2 100	718"5 100

" Billions (10⁹)Source: Siemens, Anwendungen, Verbreitung und Auswirkungen der Mikroelektronik in Oesterreich,
op. cit., p. 5.

Table 181

ELECTRONIC COMPONENTS MARKETS BY SECTOR, 1978 and 1985

(Current prices in DM)

	Germany		Western Europe		United States		Japan		Western World	
	1978	1985	1978	1985	1978	1985	1978	1985	1978	1985
Data Processing EDP	351'	745'	1"240	2"560	3"400	6"393	1"105	2"897	5"837	12"328
Telecommunications	822'	1"320	2"950	4"637	4"281	6"296	1"371	2"426	9"325	14"920
Measurement and Control Instruments	607'	956'	1"399	2"341	1"827	2"333	660	1"291	4"125	6"487
Energy	212'	292'	561'	821'	711'	1"148	318'	464'	1"660	2"615
Consumer Electronics	1"408	1"926	3"816	5"391	1"986	2"454	3"850	5"148	12"445	17"320
Domestic Appliances	132'5	188'	373'	574'	516'	758'	380'	745'	1"360	2"228
Vehicle Electronics	87'5	166'	218'	448'	515'	1"315	139'	307'	891'	2"219
Leisure Products	48'	157'	160'	473'	499'	1"033	902'	1"752	1"945	3"933
TOTAL (market share in %)	3"668 (9.8)	5"750 (9.3)	10"717 (28.5)	17"245 (27.8)	13"735 (36.5)	21"730 (35.0)	8"725 (23.2)	15"030 (24.0)	37"597 100	62"050 100

' Millions (10⁶)" Billions (10⁹)Source: Siemens, *Ibid.*, p. 6.

Table 19
USE OF INTEGRATED CIRCUITS BY SECTOR IN 1978 and 1985
(Current prices in DM)

	Germany		Western Europe		United States		Japan		Western World	
	1978	1985	1978	1985	1978	1985	1978	1985	1978	1985
Data Processing EDP	190'	506'	710'	1"814	1"800	4"390	750'	2"366	3"290	8"904
Telecommunications	155'	440'	430'	1"292	1"000	2"376	360'	879'	1"860	4"961
Measurement and Control Instruments	155'	374'	330'	861'	575'	775'	200'	608'	1"145	2"417
Energy	10'	44'	30'	123'	75'	310'	20'	101'	140'	509'
Consumer Electronics	300'	638'	650'	1"476	300'	620'	620'	1"285	1"925	4"325
Domestic Appliances	12'	33'	40'	123'	150'	310'	80'	338'	295'	763'
Vehicle Electronics	14'	66'	35'	185'	250'	878'	20'	101'	310'	1"272
Leisure Products	24'	99'	75'	276'	250'	671'	400'	1"082	835'	2"289
TOTAL	860' (8.8)	2"200 (8.6)	2"300 (23.5)	6"150 (24.2)	4"400 (44.9)	10"330 (40.6)	2"450 (25.0)	6"760 (26.6)	9"800 100	25"440 100

' Millions (10⁶)

" Billions (10⁹)

Source: Siemens *Ibid.*, p. 7.

trade and relative prices. Predictions are made relative to a base run in which the microelectronics revolution is assumed to not occur at home or abroad and the trend growth of productivity remains at 4 per cent per annum. The forecasters then assume that the microelectronics revolution will mean that productivity growth will return to its early 1970s trend of 5 per cent per annum, and relative to the base run, by 1990:

- i) productivity abroad will be 10 per cent higher
- ii) production abroad will be 6 per cent higher
- iii) world trade will be 8 per cent higher.

At home, microelectronics will cause production costs to fall, but exports will not be priced below world levels. Two scenarios are then analysed. In Scenario A, Dutch labour productivity, through process innovation, will increase at the world rate so that by 1990, it is 10 per cent higher relative to base. (Embodied labour saving, embodied capital saving, disembodied labour and capital saving are all allowed for. Product innovation making 5 per cent of all machines obsolete to 1990 is assumed to lead to investment to replace the capacity lost). In Scenario B the Netherlands only introduces microelectronics at half the world rate, a major consequence being a foreign trade effect reducing exports by 1/2 per cent per annum and increasing imports by 1/2 per cent per annum.

The effect on leading economic indicators from these two scenarios is shown in Table 20. These results, however, only reflect mainly direct effects. In Scenario A where the rate of introduction matches the world rate, 12 per cent productivity growth is matched by 6 per cent output growth. i.e. we have 50 per cent compensation of output. It is then shown that if investment is higher by 5 per cent per annum in each year in the 1980s this will mean 40,000 more jobs by 1990. One per cent per annum lower wage increases will mean 130,000 extra jobs by 1990 mainly through export price effects. This gives some indication of the strength of extra compensation effects but unfortunately the model does not (apparently) consider these as endogenous reactions. The outcome of the model is thus that introducing new technology will mean lower employment relative to base if the compensation effects are not strong enough. However it is shown what compensation is necessary to prevent unemployment rather than what compensation one would expect to occur in reaction to the new technology. Finally we should state that the model builders produce estimates for 1990, as they feel that 1985 would be too early to see any real effect.

Table 20

NETHERLANDS - EFFECTS OF MICROELECTRONICS
MACRO SIMULATION 1980-1990 RELATIVE TO A BASE RUN

	% Increase Over Base	
	Scenario A	Scenario B
Production	6	0
Labour Productivity	12	6
Unemployment (1,000 persons)	170	160
Investment	21	8
Bal. of Payment on current A/c (% of NNP)	-1	-3

Source: Rathenau Report, pp. 101-102.

The work of Whitley et al (1981) gives results for a simulation exercise on a United Kingdom macro model. In this case there is an input output representation of the technology. Again the results are to be considered illustrative rather than firm forecasts. In the first case microelectronics is assumed to change the growth of productivity between 1985 and 1990, upwards, relative to a base projection. The details of the outcome are shown in Table 21. Overall the effects of microelectronics is to increase trend optimal productivity growth by just under 0.7 percentage points per annum with actual productivity growth growing faster by 0.5 percentage points per annum.

To indicate the sensitivity of employment to changes in productivity "when the various macroeconomic feedbacks through costs, price increases, trade, adjustment lags and the multiplier are allowed to operate", in aggregate these feedbacks provide a 60 per cent compensation to the initial displacement through productivity increase. It is however argued that even this list of compensation effects is incomplete. Because of the difficulty of getting detailed information on the change in productivity likely to result from microelectronics a second case is analysed covering a restricted sample of industries. In this, compared to base run, a faster rate of diffusion compared to competitors is assumed. It is then argued that in addition to the feedbacks already considered:

1. that to achieve the increase in productivity investment must rise considerably;
2. foreign trade performance will improve because of improvements in non-price competitiveness;

Table 21

EFFECTS OF CHANGING OPTIMAL PRODUCTIVITY: PERCENTAGE DIFFERENCES
FROM BASE LINE VIEW IN 1990. UNITED KINGDOM

Industry group	1 Optimal output per man	2 Output per man	3 Output	4 Employment	Elasticities		
					ϵ_1 (4 + 1)	ϵ_2 (3 + 1)	ϵ_3 (2 + 1)
Agriculture	5.5	4.0	1.0	-2.8	-0.51	0.18	0.73
Mining	6.2	8.0	2.1	-5.3	-0.85	0.34	1.29
Food, drink and tobacco	1.7	1.1	0.7	-0.5	-0.29	0.41	0.65
Chemicals	4.8	1.4	0.6	-0.7	-0.15	0.13	0.29
Metals	4.1	4.3	2.0	-2.0	-0.49	0.49	1.05
Engineering, of which	2.8	5.2	1.4	-1.8	-0.64	0.50	1.14
Mechanical engineering	2.7	1.9	0.2	-1.7	0.70	0.07	-0.63
Electrical engineering	5.0	4.3	1.8	-2.4	0.86	0.36	-0.48
Motor vehicles	4.5	2.0	1.6	-0.5	0.44	0.36	-0.11
Textiles and clothing	4.3	4.3	2.1	-2.1	-0.49	0.49	1.00
Other manufacturing	4.7	3.6	1.4	-2.1	-0.45	0.30	0.77
Construction	5.3	3.0	-0.3	-3.2	-0.60	-0.06	0.57
Public utilities	6.2	2.7	1.5	-1.0	-0.16	0.24	0.44
Transport and communication	3.6	1.6	0.1	-1.5	-0.42	0.03	0.44
Distribution	2.9	2.0	0.7	-1.3	-0.45	0.24	0.69
Professional services	n.a.						
Miscellaneous services	2.1	1.6	0.9	-0.7	-0.33	0.43	0.76
Manufacturing	3.8	3.0	1.2	-1.7	-0.45	0.32	0.79
Services	2.6	1.4	0.7	-0.7	-0.27	0.27	0.54
Total	3.5	2.4	0.9	-1.4	-0.40	0.26	0.69

Excluding North Sea oil and gas.
Source: Whitely et. al. (1981).

3. technological change will affect intermediate demands;
4. technological change will change the composition of consumer demand.

The employment implications of the reactions are to be considered additional to the 60 per cent compensation found above.

In Table 22 the results are detailed. Column (1) gives the overall effects of new technology by 1990 relative to a continuation of the United Kingdom's previous performance. Column (2) illustrates the impact of new technology allowing for the compensation effects normal in an input output framework i.e. the 60 per cent compensation discussed above, columns (3), (4) and (5) give details of extra compensation coming from changes in final demands (FD), intermediate demands (ID) and trade (T) that can be expected to flow from the faster adoption of microelectronic technology. It should be stressed that these figures are not forecasts, they must only be considered as indicative of the strength of compensation effects.

Table 22

EFFECTS OF FASTER TECHNOLOGICAL CHANGE
RELATIVE TO BASE RUN UNITED KINGDOM

	(1) Overall	(2) Prod	(3) FD	(4) ID	(5) T
GDP %	4.2	0.6	0.6	-	3.0
Employment ('000s)	542	-168	165	4	541
Bal. of Payments (£b)	4.4	0.4	4.7	.1	8.6

One might note that the trade effect is very strong. This reflects the view expressed in the United Kingdom National Commission report.

This model then makes a number of compensation effects endogenous to the model and these generate 60 per cent compensation. However it is argued that even these do not fully register the impact of new technology and the work suggests that once trade effects arising from relatively fast diffusion are fully taken into account then a positive impact on labour demand can be identified.

Zeman and Rahn (1980) have investigated the impact of microelectronics in the Canadian economy by simulating a macroeconomic model(1). They look at the impact on certain economic indicators of different combinations of diffusion speed and productivity gain potential of the new technology. Their results on unemployment are detailed in Table 23. Their conclusion is that "small increases in productivity have little effect on the long-term employment trend. It appears that only extremely high rates of productivity increase and rapid diffusion rates can lead to rapid declines in employment". We shall argue below that rapid diffusion is not expected and we have not found any suggestion that microelectronics yields a 1,000 per cent potential productivity again.

In the Dutch report some useful figures on the impact of different rates of productivity growth on employment with fixed output levels are presented (Table 24). These figures give some idea of how sensitive is employment to different rates of introduction of microelectronics when no compensation effects exist to increase output. As one can see, with fixed output, 1 per cent extra on productivity growth in manufacturing and services means 300-350,000 fewer jobs p.a. We should not, however, expect output to be independent of productivity growth.

In the Austrian study the authors present five scenarios for 1985 and 1990 on the assumption that the increase in the growth of labour productivity originating from the application of microelectronics is not added to the exponential trend of 1970-76 but to the lower productivity increases of the period 1976-80. Thus, microelectronics compensates to some extent for the recently reduced rate of productivity increase and raises it back to the level of the first half of the 70s. This is similar to the Dutch assumptions.

1. "The model includes both 'pessimistic' and 'optimistic' components as well as neutral elements There is job-deplacement via reductions in labour intensity induced by increased technology in use. There is job creation via increases in various components of Demand....international effects are included via separate Export/Import functions."

Table 23

UNEMPLOYMENT, DIFFUSION,
AND POTENTIAL PRODUCTIVITY GAINS - CANADA

Potential Productivity gain over base %		Unemployment in 1990 relative to unemployment in 1980 %	
Services	Manufacturing	Diffusion	
		Fast	Slow
150	150	83%	63%
150	1,000	60%	60%
1,000	150	190%	110%
1,000	1,000	186%	107%

Source: Calculated from graphs in Zeman and Rahn (1980).

Table 24

EMPLOYMENT AND PRODUCTIVITY GROWTH
WITH FIXED OUTPUT LEVEL - NETHERLANDS

Sector	Production, 1975 guilders (billions) 1990	Prod. Growth % p.a.		
		(a)	(b)	(c)
Agriculture	16.0	4.9	4.9	4.9
Building	16.3	1.8	1.8	1.8
Manufacturing	108.6	4	5	6
Services	172.7	3	4	5
Government	30.8	-	-	-
Employment 1990 ('000s)		5,307	4,947	4,607
Unemployment 1990 ('000s)		291	651	991

Source: Rathenau Report, p.63.

The Austrian study uses a fairly complex formal structure(2). Basically, the analysis is carried out in three steps, which are partly interrelated, however. Firstly, an econometric forecasting model for the final demand for goods and services and an input-output model (26 sectors) are used for the derivation of labour demand. Secondly, a demographic and educational model is used for forecasting labour supply. Thirdly, by putting together labour demand and supply figures a forecast of expected unemployment is produced.

All three basic elements of the model are linked together. The econometric demand model is fed with certain data on demography and on the labour market provided by the demographic and educational model. Final demand for goods and services is then translated into a vector of gross production values using the input-output-inverse. The gross production values are consequently transformed into labour demand by categories by applying vectors of labour coefficients (inverted labour productivity).

To illustrate the procedures consider the following example. If microelectronic technological change leads to a reduction in labour coefficients, this tends to lead to a reduction in labour demand at a given level of final demand. At the same time overall productivity in the economy may grow. By assuming a reaction by unions and thus an increase in wages, total demand may increase as a consequence of consumption growth. Thus, the compensation effects appear. Taking account of all such effects at least some of the initial labour displacement will disappear. At the same time, the forecasting exercise details changes in educational requirements as labour demand changes.

As mentioned, the authors of the Austrian study present five scenarios. They refrain from deciding which of them appears as most probable.

The main differences between the first three scenarios rest on the following assumptions, which are fed into the model described above:

1st Scenario: Rapid diffusion of wholly imported micro-electronic technology in the production process and constant working time at the 1980 level.

2. For a more detailed description of the methods applied see Anwendungen, Verbreitung und Auswirkungen der Mikroelektronik in Oesterreich op. cit., pp. 87-08 as well as Dell'mour (1980).

2nd Scenario: Reduced diffusion speed of wholly imported microelectronic technology and further reduction in working time in accordance with the trend of 1970-1976.

3rd Scenario: Reduced diffusion. Production of microelectronic technology domestically (not chips). Reduction of working time as in the second scenario.

In addition, there is a fourth scenario which consists of a modification of the second insofar as there is a reduction of labour supply following an assumed lowering of the working age of certain categories of workers. The fifth scenario, finally, depicts the situation which might theoretically be possible if there were a 100 per cent application of microelectronic technology, wholly imported and at the same time a constant working time at the 1980 level.

Some of the quantitative results following the comparison of the first three scenarios with alternative standard development variants are summarised in Table 25. The picture is striking. The most important observations that can be made are the following:

- The introduction of microelectronics in the production process of the Austrian economy shows important negative overall effects on employment.
- The diffusion speed of microelectronic technology is important. But also important is the proportion of microelectronic technology produced domestically. The larger is this proportion, the lower are the net employment effects.
- The pattern of reductions in working time has the same effect on employment as do changes in the diffusion speed.
- The structural effects of microelectronics (independently of the diffusion speed, working time and proportion of domestic production of microelectronics) is always to the detriment of less qualified manpower and women. However more qualified manpower will enjoy a positive employment effect from microelectronics.

From the model used by the authors it follows logically that scenarios nos 4 and 5 alleviate and aggravate employment problems respectively.

We do have some doubts about the compensation effects incorporated in the Austrian exercise. According to the representation of that model in Dell'mour (1980) the final demand vector is only loosely linked to productivity performance. Although incomes feedback on to demand we cannot see any feedback of prices. It seems

Table 25

EMPLOYMENT EFFECT OF MICROELECTRONICS IN AUSTRIA FOR THE YEARS 1985 and 1990

Three Scenarios

	Scenario 1				Scenario 2				Scenario 3			
	1985		1990		1985		1990		1985		1990	
	Abs.	%	Abs.	%	Abs.	%	Abs.	%	Abs.	%	Abs.	%
Employed persons in 1'000	-137.7	-4.3	-165.8	-5.2	-106.5	-3.3	-136.1	-4.0	-0.6	0	-47.3	-1.4
Employed men in 1'000	- 77.2	-4.1	- 82.1	-4.4	- 60.5	-3.1	- 70.0	-3.5	+5.9	+0.3	-14.4	-0.7
- University	+ 0.8		+ 3.1		+ 0.4		+ 1.8		+3.3		+ 4.6	
- High School	+ 0.7		+ 4.0		+ 0.1		+ 2.2		+5.5		+ 7.1	
- Technical School	- 1.0		+ 0.8		- 1.0		- 0		+2.8		+ 3.3	
- Other	- 77.8		- 89.9		- 60.0		- 75.0		-5.8		-28.8	
Employed women in 1'000	- 60.4	-4.6	- 83.7	-6.3	- 45.9	-3.4	- 66.1	-4.7	-6.5	-0.5	-32.9	-2.3
- University	+ 0.4		+ 1.1		+ 0.2		+ 0.7		+1.0		+ 1.5	
- High School	- 0.3		+ 0.8		- 0.4		+ 0.2		+2.8		+ 3.2	
- Technical School	- 14.0		- 25.0		- 10.2		- 18.6		-3.6		-12.8	
- Other	- 46.6		- 60.6		- 35.6		- 49.0		-6.7		-24.3	
Potential unemploy- ment in 1'000 persons	+137	+67.5	+166	+75.9	+106	+89.8	136	+460	0	0	+47	+162.1

Source: Anwendungen, Verbreitung und Auswirkungen der Mikroelektronik in Oesterreich, op.cit.,
pp. 122-31.

that investment is exogenous and "exports and imports are determined by logistic functions depending on the gross domestic product"(3). Prices seem to play no role in these functions. Given the relative importance of technology multiplier effects through investment and also the importance of trade effects in both the Dutch exercise and in the Whitley (1981) model (which is itself very similar to the Austrian) these seem to be major deficiencies that may well be contributing to the relatively pessimistic conclusions. The compensation effects included, however, suggest that if we consider that the effect of microelectronics is to increase the trend rate of growth of productivity by 1 percentage point per annum, then by 1990 under Scenario's 1 and 2 there is 50-60 per cent compensation (see figures in Table 25). The results for 1985 however are much less optimistic, in Scenario 1 there is only 14 per cent compensation although under Scenario 3 100 per cent.

Table 26
THE EFFECT OF AUTOMATION 1981-1990
FINLAND

Effect on	Percentages	
	Scenario	
	1	2
Lab Productivity	6.0	22.0
GDP	5.0	8.5
Direct Employment Effect	-4.5	-8.5
Indirect Effects	+3.5	+10.0
Total Effect	-1.0	+1.5
Effect on Unemployment	+0.7	-0.9

In the Finnish report the results of a modelling exercise are presented, unfortunately we have no details on the model itself. Two scenario's are considered the first with automation in Finland at the same rate as abroad, and the second with faster diffusion than overseas. The effects are detailed in Table 26. As we see, in Scenario 1, without any foreign trade gains, 78 per cent of the direct employment effects are compensated for, compared to 60 per cent in Whitley et al. However once one allows for foreign trade gains in Scenario 2,

3. Dell'mour, (1980) pp. 9-10.

compensation more than offsets the direct employment effects.

For Sweden Eliasson (1980) uses a micro to macro model to simulate the effects of technical change. His conclusion is that there will be more or less full employment in the long run. To quote:

"The simulations do not support the contention that large disequilibrium situations will be maintained for long in an economy where market price mechanisms are allowed to function reasonably well. Technical change creates indirect demand ..."
(p. 25)

and

"Our clear conclusion is that it is far worse for employment in a country during a medium term adjustment period to see technical change appear through price pressure from foreign competitors than to see fast technical change originate in leading domestic industries." (p. 24)

The study dealing with the Federal Republic of Germany is: "Technischer Fortschritt - Auswirkungen auf Wirtschaft und Arbeitsmarkt"(4). As in the case of the other studies there is only limited space to present the approach selected by the authors. Emphasis will again be placed on the results concerning the labour market.

The German report differs from the other reports not only in results but also in the methods applied. The authors of the German report choose the broad framework of systems analysis. They incorporate in their study a vast amount of quantitative as well as qualitative information and tie it together in an iterative process which is not reproduced in the published documents. We are not able to subject their basic model to close scrutiny.

In contrast to other studies the authors of the German study identify a most probable path of development reflecting the expected increase in the economy's propensity to innovate for the period 1977-1990.

4. For a short description see Prognos and Mackintosh Consultants (1981). Thanks are due to Hans Browa from Prognos Ltd (Basle), who provided the authors with an English summary of the report which proved very helpful in the course of writing this review.

The picture following this forecasting exercise shows many interesting features, three of which we detail here, the others being discussed below.

1. The expected increase in the propensity to innovate does not affect the overall development of employment. Whether or not the assumption of higher propensity to innovate holds, total employment is forecast to remain virtually constant comparing 1977 and 1990.
2. Independent of the cyclical pattern of economic activity the level of employment is expected to decrease somewhat until 1985 and will only pick up again later. Technical, economic and social constraints are responsible for this.
3. Finally, combined with the expected path in labour supply determined by demographic factors the resulting figures of registered unemployment are:

1977	1.0 million
1985	1.65 million
1990	1.2 million

These figures exclude the so-called "hidden reserves" in the labour market. These are expected to increase from 700,000 persons in 1977 to 1,000,000 persons in 1990. The proportion of frictional unemployment is also expected to rise (400,000 persons in 1990).

The German evidence would be incomplete if we failed to mention the report produced in competition to the one treated here, namely the Ifo-study bearing the same title(5). This not only followed a different methodology but also has contrasting results. The Ifo-study uses scenarios which were worked out on the base of a disaggregated macro-economic model. The most probable scenario is assumed to be one which involves a steady continuation of past rates of technological change. It is further assumed that reductions in working time continue as in the past. Alternatively, there is a second scenario, which assumes faster reductions in working time as well as slowed-down technological change following so-called "rationalisation protection agreements"(6) between employers and unions.

-
1. For a shortened presentation see Scholz (1980).
 2. The German original term is "Rationalisierungs-schutzabkommen".

The main results can be described as follows.

1. Irrespective of the scenario chosen, the growth rate of labour productivity will continue to be greater than the growth of production during the 80s. Specifically, the main scenario shows a reduction in employment by 500,000 persons between 1980 and 1985. Afterwards, the total employment figure is expected to remain constant.
2. The demographic process continues to lead to growing numbers in the potential labour force. The potential labour force will reach its maximum only in the second half of the 80s. The expected increase, in the main scenario, is 500,000 persons between 1980 and 1990.

From these results follows a more pessimistic overall picture concerning unemployment. In industry, compensating demand increases are not expected to match productivity growth. Services within industry or outside (in the traditional sense of the term) are not considered as a sufficient source of compensating employment growth either. The unemployment forecast in the Ifo-study does not, however, lie outside the range of other existing forecasts for Germany.

All the results discussed above are derived by the use of large macro economic models. Not all results derive from such models however.

In the case of France, the Nora Report concluded that in some sectors there would be job savings of up to 30 per cent. The reasoning was based on a constant level of production, without any compensatory effects and without prejudice to the reassignment of the personnel concerned. The study by Pastré et al concludes, for its part, that by 1985 the use of the eight main "advanced automatic systems" is likely to lead to the direct loss of 210,000 jobs. The reasoning here is based on the same assumptions as in the Nora Report. Relaxing some of these assumptions leads one to conclude that the number employed will stabilise despite slow growth in the level of output. This stabilisation is the result of very widespread job creation and loss (as detailed in Table 27).

There is no national study on the employment impact of electronic based technologies in Switzerland available at present. There is, however, a study that was privately financed, which sheds some light on prevailing expectations in that country. D. de Meuron (1981) led an extended number of interviews at the level of branch organisations and individual enterprises. He then organised his information within the framework of a broad analytical model and arrived at some quantitative

Table 27

PROJECTED IMPACT OF MICROELECTRONICS, FRANCE

	45 702	12 625	23 308	160 240	35 933	177 720	93 230	378 718	95 173	1 734	262 778	169 951	393 441	23 431	94 201	391 373	260 268	405 940	210 739	513 736	25 163	87 403	112 653	203 941	221 422	94 201	87 403	875 007	TOTAL
Fisheries, forestry and agriculture....																													77 054
Water, gas, electricity.....		+																											140 802
Oil and liquid fuels.....		+	+																										44 220
Solid mineral fuels.....																													2 048
Mining, miscellaneous minerals.....																													55 907
Fabricated metal products.....			+	+	+																								204 846
Basic metal industries.....			+	+	+																								305 313
Mechanical engineering.....			+	+	+																								456 281
Motor vehicles, ship and aircraft build.			+	+	+																								916 818
Electrical engineering and electronics.			+	+	+																								488 124
Glass.....																													74 482
Ceramics and building materials.....			+	+	+																								139 643
Construction.....																													163 863
Chemicals, rubber, asbestos.....			+	+	+																								446 630
Agro-food.....			+	+	+																								358 018
Textiles.....																													378 042
Clothing.....																													245 437
Leather and skins.....																													118 221
Wood and furniture.....																													184 117
Paper and paperboard.....			+	+	+																								137 764
Printing and publishing.....																													183 838
Other manufacturing.....																													185 309
Transport.....																													614 460
Food and beverages.....			+																										353 120
Non-food retailing.....																													141 169
Banking and insurance.....																													474 890
Other services.....		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	741 072

SECTORS

QUALIFICATIONS

Agricultural and forestry workers and fishermen.
 Engineers and technicians (agr. and agro food).
 Engineers (mathem., management, data processing).
 Other engineers.
 Foremen.
 Testing and checking technicians.
 Job engineers.
 Supervisors.
 Project designers.
 Design draughtsmen.
 Specialist skilled workers.
 Other skilled workers.
 Semi-skilled workers and labourers.
 Skilled warehouse porters.
 Drivers.
 Transport workers.
 Higher management.
 Secretaries.
 Accountants and cashiers.
 Other qualified administrative workers.
 Analysts and programmers.
 Card-punch machine operators.
 Higher management, retailing.
 Technical salesmen.
 Skilled retail trade salesmen.
 Higher management, finance.
 Qualified financial personnel.
 Others.

Key: + foreseeable increase in employment

- foreseeable decrease in employment

Source: Pastré et al., 1981

conclusions on the expected development of employment for the coming few years (medium term forecast). The method of analysis applied by the Swiss author is less sophisticated than the methods used by the authors of the studies previously reviewed. The Swiss study can, therefore, only be taken as a first bit of quantitative information on expectations in industrial circles.

De Meuron's results are:

1. The introduction and application of electronic based technologies in Switzerland will lead to changes in the structure of employment with a constant or slightly rising level of total employment in the medium term.
2. In general, the negative impact will be mostly felt in the area of less qualified manpower. The beneficial effects are expected to arise mainly in the manufacturing of machinery. Services are likely to expand further, implying that female labour will not suffer particularly.

The particulars are summarised in Table 28.

In the New Zealand report it is stated that:

"The consensus among those concerned with manufacturing is that the new technology will have minimal effect on employment in the next five years".

However types of employment might change and unless there is some synchronisation with the availability of other jobs the social consequences of unemployment could be extremely disruptive (New Zealand, p. 35/36). The Dutch also consider that five years is too short a period for the effect to show. This distinction between the long and the short term is an important one, and the choice of time period can significantly affect one's forecasts.

The Australian report argues that technological change may reduce jobs but there are sufficient unsatisfied needs, the fulfilling of which can create jobs for all. It does not say they will be fulfilled. In the Norman (1980) paper it is argued that:

"The microelectronic revolution is thus likely to have major impacts on the number and types of jobs available in the industrial world over the next few decades. But every expert who has studied the potential employment impact of microelectronics has reached the same conclusion: more jobs will be lost in those countries that do not pursue the technology rigorously than in those that do." (p. 40).

Table 28
CURRENT TENDENCY IN ANNUAL EMPLOYMENT CHANGE
IN THE MEDIUM TERM IN SWITZERLAND

Annual Rate of Employment Change	Industries	Proportion in Total Employment 1975
0%	Hotels and restaurants; wholesale trade; building fittings; maintenance and repairs; metal products; road transport; telecommunications; measuring instruments; urban transport	19.8%
+ 2%	Construction	8.3%
reduction < 2%	Primary sector; food products; chemicals; wood and furniture; graphic arts; railways; construction materials; energy; paper and paperboard; motor vehicle construction; beverages; household electrical appliances; footwear	23.6%
reduction = 2%	Textiles and clothing; tobacco	3.3%
2% < reduction 4%	Watches and clocks	2%
growth < 2%	Retail trade; machinery; advice bureaux; general government; electronics and electrical engineering; postal services; insurance; plastics, leather, rubber; culture, sport, air transport	27%
growth < 4%	Banking	2.7%
growth = 2%	Hospitals; education; public health; welfare activities	8.4%
unknown	Other branches	5%

Source: de Meuron, D., Micro-électronique et emploi en Suisse, op. cit., p. 104-6.

Jenkins and Sherman (1979) however consider that it is not unrealistic to expect job reduction of 5.2 million over 25 years in the United Kingdom (23.2 per cent of the 1978 United Kingdom labour force). Their argument, however, tends to ignore any compensation effects.

To summarise, there is no doubt that future technological changes have the capacity to reduce the number of jobs required to produce a given level of output. We have however shown that compensation effects can ameliorate this situation by stimulating output. The question is whether they are sufficiently strong and sufficiently automatic to prevent high levels of unemployment, in the short, medium and longer terms.

In general the models are reasonably optimistic on this point suggesting, in most cases that significant compensation effects do exist. The differences in the results however can be illuminating. The following factors seem to be important in defining the employment impacts in the models.

- i) The level and timing of the productivity impact of microelectronics. This reduces to what potential productivity gain microelectronics gives rise to, in what industries, and how quickly the technology will be applied. The Dutch exercise and the Austrian exercise suggest something in the region of an extra one percentage point on the trend rate of productivity growth (of the late 70s) can be realised. The greater is the potential and the faster it is realised (the faster is diffusion) the greater will be the direct negative effects on employment. One should realise however that to raise trend productivity growth by 1 percentage point per annum for at least 10 years is a really dramatic improvement.
- ii) Any change in productivity will give rise to changes in prices, incomes, intermediate demands etc. If output is not allowed to change in response to productivity growth then labour demand will fall. The models above suggest that something between 50 and 86 per cent of the fall is offset by normal compensation effects by 1990.
- iii) On top of these normal compensation effects we have those extra effects, primarily through trade that come from a rate of productivity increase above that of competitors. These, from the Dutch, Finnish, United Kingdom and Swedish exercises, can be very strong.

In general the models are optimistic, the Austrian and Ifo study of Germany being most pessimistic. In the Austrian model compensation effects through prices and trade do not seem to carry much weight. We cannot make much informed comment on the Ifo study except to say that its results are contradicted by the other German study. Of course where no compensation effects are allowed for one would expect pessimistic forecasts. In general we suggest from the above models that something in excess of 60 per cent of the direct fall in labour requirements is compensated for, the amount in excess of this being unclear but if a rate of technological advance faster than that of competitors is involved then the total can exceed 100 per cent, and the majority of these models seem to suggest that it will approximate 100 per cent.

Finally we should note the following:

- i) In the models the impact on labour demand may vary as the time period analysed varies. Most results are for 1990 relative to 1980-81. By some it is argued that 1985 is too early a date from which to look for any effect, whereas the Austrians show significant negative effects by 1985.
- ii) The Austrian study in particular illustrates that an indigenous industry producing the capital goods incorporating the new technology is one of the keys to capturing technology multiplier compensation effects. Without such an industry these effects may not be realised.
- iii) Faster diffusion has negative direct but positive indirect effects. The effect of faster diffusion speeds is thus not always clear, see for example Stoneman (1982).
- iv) This discussion has concentrated on labour as an aggregate. It is shown in these models that skill and industrial structures will change in response to the new technology and we consider this further below.
- v) These models illustrate that before one can provide an unemployment forecast one must have details on labour supply. This is also considered below.

3.1.2. Future demands by skill

The Australian and the Dutch reports echo a forecast of many reports including those discussed above, that the likely new technology will increase the number and range of skilled intellectual tasks and decrease the number of unskilled tasks. The Norwegians however see further extension of the polarisation view. The

Japanese report attempts to quantify some of these effects by looking at the effect of microelectronic technology on labour in three categories - software engineers, process workers and sales people. The most interesting point is that minimum, medium and maximum forecasts associated with slow, medium and fast diffusion are presented. See Table 29.

Table 29
LABOUR DEMANDS BY OCCUPATION:
JAPAN 1975-1985

Occupation	Change in requirements 1975-1985 (000's)		
	Min	Med	Max
Software Engineers	+201.3	+368.4	+715.3
Process Workers	+349	+203	+ 64
Salespeople	+ 12		+ 6

These figures suggest that there will be a shift from unskilled to skilled jobs, but that shift is the faster the faster is diffusion. Fast diffusion not only destroys jobs faster it also creates them faster. However the jobs created will be different from those destroyed and thus although there will be jobs, there is still an adjustment problem to be solved. That problem will be the greater the faster is the diffusion. When it comes to talking of labour of different skills +1 and -1 do not sum to zero. The profile of labour supply in terms of qualification changes quite slowly. This is especially true for changes requiring more skills and higher qualifications.

The French view is that the number of people employed in information (excluding acquisition) will probably total 230,000 by 1985 (Tebeka, 1980). It must be noted, however, that there are opposing trends within this forecast (Cossalter and Denis, 1981). The number employed in data collection, for example, can be expected to decline (22 per cent of employed in 1985, compared with 35 per cent in 1979). With regard to non-information qualifications, many reports forecast substantial job creation [in the new services linked with the operation of data banks or domestic telematics for example (P. Bonnelli and A. Fillion, 1980)]. However, this job creation would seem unlikely to occur before the end of the period. Where job losses are

concerned, a number of studies suggest that some qualifications are threatened more than others by the spread of microelectronics. This is true in particular for draughtsmen or accountants and, more generally, for office jobs which have hitherto been a source of considerable job creation (VIIIth Plan, 1981). One study showed, for example, that broadly speaking the qualifications that were the most job-creative during the period 1968-1975 would be those most directly affected by the new forms of computerisation (Pastré et al, 1981).

The German report sees a growing need for a more highly qualified labour force. The details are contained in Table 30. Groups benefitting are workers with technical or academic backgrounds in more general as well as in specialised functions and workers with adaptable intermediate skills. On the losing side there are the unskilled and semi-skilled workers and the workers with certain specialised skills (e.g. office clerks, bricklayers, printers).

At a less disaggregated level we have forecasts for the United States based on three different future scenarios; in the first, low trend, there is a decline in the rate of labour force expansion, continued high inflation and modest increase in production and productivity. In high trend I there is high labour force growth, in high trend II there is higher productivity. The results are shown in Table 31. As can be seen the choice of scenario does not affect the distribution very much, white collar will grow relative to blue collar and non private household service work will also grow considerably.

Finally in this section we refer to a forecast for a much shorter term. In Japan(7) we have results on NC machine tool potential users and their future employment plans to 1983. The data indicates that increases in employment are most likely to occur for NC machine tool operators and declines are mostly likely for casting workers. This illustrates the problem of skills and new technology quite neatly. An unemployed casting worker is unlikely to be a suitable candidate for the post of NC machine operator.

7. Research and Study concerning Influences on Microelectronics, Employment and Results of the Survey on Labour Statistics by Occupation in Fiscal Year 1980, Ministry of Labour, Foreign Press Center, Japan, 1981.

Table 30
ECONOMICALLY ACTIVE PERSONS BY TYPE
OF ACTIVITY IN GERMANY, 1977 to 1990

Field of Activity	Economically active persons		Change compared to 1977		Economically active persons: percent of total	
	1977	1990	In 1'000 in %		1977	1990
1. Mainly management functions	922	1'104	182	19.7	3.7	4.4
2. Office work	3'863	3'611	-252	-6.5	15.5	14.4
3. Entertainment, publishing	125	152	27	21.6	0.5	0.6
4. Education	897	1'076	179	20.0	3.6	4.3
5. Cleaning operations	872	1'002	130	14.9	3.5	4.0
6. Installation, repair and maintenance of machinery	2'224	2'695	471	21.2	8.9	10.8
7. Specialised consulting, research and development	1'171	1'604	433	37.0	4.7	6.4
8. General supply services	2'343	2'150	-193	-8.2	9.4	8.6
9. Special supply services	498	470	-28	-5.6	2.0	1.9
10. Assemblers and assistants	2'467	2'144	-323	-13.1	9.9	8.6
11. Rail transport	199	165	-34	-17.1	0.8	0.7
12. Road and sea transport	748	797	49	6.6	3.0	3.2
13. Operating processing plants	1'396	1'000	-396	-28.4	5.6	4.0
14. Special tasks in manufacture of metal products	780	801	21	2.7	3.1	3.2
15. Special tasks in construction	1'371	1'095	-276	-20.1	5.5	4.4
16. Special tasks in food, beverages, tobacco	501	531	30	6.0	2.0	2.1
17. Special tasks in agriculture	1'610	1'372	-238	-14.8	6.6	5.5
18. Special tasks in mining	151	132	-19	-12.6	0.6	0.5
19. Special tasks in manuf. of clothing	200	200	0	0	0.8	0.8
20. Special tasks in printing	151	104	-47	-31.1	0.6	0.4
21. Transmission of information	176	157	-19	-10.8	0.7	0.6
22. Health services	727	917	190	26.1	2.9	3.7
23. Legal advice, business consultancy	126	158	32	25.4	0.5	0.6
24. Security functions	927	1'120	193	20.8	3.7	4.5
25. Test, measurement & co.	376	371	-5	-1.3	1.5	1.5
26. Others	100	64			0.4	0.3
TOTAL	24'921	24'992	71	0.3	100	100

Source: Technischer Fortschritt - Auswirkungen auf Wirtschaft und Arbeitsmarkt, op.cit., p. 142.

Table 31

EMPLOYMENT BY MAJOR OCCUPATIONAL GROUP, ACTUAL 1978,
AND ALTERNATIVE PROJECTIONS FOR 1990, UNITED STATES

(numbers in thousands)

Occupational Group	1978		1980						Percentage change in employment 1978-80		
			Low Trend		High-Trend I		High Trend II		Low-Trend	High-Trend I	High-Trend II
	Number	Percent	Number	Percent	Number	Percent	Number	Percent			
Total	87,610	100.00	119,590	100.00	127,907	100.00	121,447	100.00	22.5	31.0	24.4
White-collar workers	49,608	49.8	60,730	50.9	64,712	50.6	61,570	50.7	24.9	33.1	26.7
Professional & technical workers	15,568	15.9	20,038	16.8	21,119	16.5	20,295	16.7	28.7	35.7	30.4
Managers & administrators	8,802	9.0	10,484	8.8	11,257	8.8	10,677	8.8	19.1	27.9	21.3
Salesworkers	6,420	6.6	7,989	6.7	8,632	6.8	8,079	6.7	24.4	34.5	25.8
Clerical workers	17,818	18.3	22,219	18.6	23,705	18.5	22,191	18.5	24.7	33.0	26.4
Blue-collar workers	31,812	32.6	37,720	31.5	40,694	31.8	38,330	31.6	18.6	27.9	20.5
Craft & kindred workers	11,705	12.0	14,366	12.0	15,555	12.2	14,658	12.1	22.7	32.9	25.3
Operatives	14,205	14.6	16,399	13.7	17,697	13.8	16,584	13.7	15.4	24.6	16.8
Non-farm labourers	5,902	6.0	6,955	5.8	7,441	5.8	7,078	5.8	17.8	26.1	19.9
Service workers	14,414	14.8	18,946	15.8	20,074	15.7	19,220	15.8	31.4	39.3	33.3
Private household workers	1,160	1.2	982	0.8	993	0.8	988	0.8	-15.4	-14.4	-14.9
Other service workers	13,254	13.6	17,985	15.0	19,081	14.9	18,232	15.0	35.5	44.0	37.6
Farmworkers	2,775	2.8	2,193	1.8	2,426	1.9	2,327	1.9	-21.0	-12.6	-16.3

Note: Due to rounding, sums of individual items may not equal totals.

Source: US Department of Labour (1981).

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3.1.3. By sector

"Every industry contains possibilities for the micro technology. Some may be more vulnerable to massive change but none are immune from the effects of the new technology" (NZFL p. 10).

These differential effects on different industries will tend to lead to different patterns of employment across sectors. By investigating this we will obtain some idea of the extent to which a reallocation of labour will be necessary, but we can also approach a basic question that has underlay the technology-employment debate for some time i.e. if, as many argue, there are compensation effects in the economy, exactly what are the new jobs created going to be and what are the people re-employed going to be producing?

The French view is that the development of new services, related in particular to individual data processing, seems likely to take over from the industrial sectors which have largely exhausted their job creating potential (Nora and Minc, 1979). As regards the sectors utilising microelectronics, the studies that have been done on certain industrial enterprises (Management Scientifique, 1980, for example), or on the banking and insurance sectors (Dubrulle et Ranchon, 1980), do not lead to any clear-cut conclusion. The past studies once again show how difficult it is to separate the data processing variable from the other variables affecting the use of labour. While no absolute assertions can be made, it would nevertheless seem that two general points may be deduced from the studies already carried out. At the sectoral level, there is no real drop in the numbers employed; it may however be argued that microelectronics will cause employment to grow more slowly than if no such phenomenon had existed.

Turning now to the relative importance of the different sectors, there does seem to be a certain consensus of opinion as to the role played by computerisation in the relative decline of the industrial sector (M. Gaspard, 1981). Without referring here to the debate over the "quaternary" sector (data processing), no such consensus exists regarding the influence exerted by microelectronics on the growth of the tertiary sector. While computerisation will in time lead to the creation of a great many services, it would appear to pose a direct threat to the demand for labour in many of the traditional services (business in particular) (ETUI, 1980; FAST, 1980; VIIIth Plan, 1981). Yet it should be remembered that, because of the substantial job creation

for which it has been responsible, the tertiary sector has during the recent past been one of the main ramparts against mounting unemployment in the developed countries (VIIth Plan, 1981).

There are some frightening forecasts of sectoral unemployment effects around. For example Rada quotes an APEX report that if by 1983 one fifth of all offices in the United Kingdom use word processors then this will mean a fall of a quarter in office jobs, if output does not change. The Norwegian report seems to present a more representative view on office work:

"While we find that there is little basis for the wildest prognoses about the possibilities for automation in office work, we must emphasize that we will experience noticeable employment effects. We do not find it realistic to expect any dramatic collapse in employment in the office sector during the next few years. It is reasonable however to expect that automation in the office will gradually make it possible to decrease the ratio of increases in the number of tasks to the number of jobs, but it is impossible to say by how much. Judging from the present rate of diffusion of office automation, the full effects of these techniques will not be known for a number of years." (p. 34)

When we come to the manufacturing sector the general view is less optimistic. Apart from Arthur D. Little's projection of one million new jobs in consumer electronics, business communication, industrial electronics application and the automotive industry, the view usually taken is that there will be at least a continuation of jobless growth. The Norwegian summary is a moderate one:

"Unless there is very rapid growth in the volume of production during the 1980s industrial employment will continue to slowly decline." (p. 33)

The German exercise leads to a forecast that the structure of economic activity measured in terms of employed persons will change dramatically. Table 32 gives the details. Marked increases in the absolute number of jobs are forecast in the following: public authorities and social security, other services, electrical engineering, mechanical engineering and the manufacturing of office, computing and accounting machinery. Significant decreases in the absolute number of jobs are expected in construction, wholesale and retailing, agriculture and forestry as well as in transport. On the whole a raised propensity to innovate accentuates the structural change.

Table 32
ECONOMICALLY ACTIVE PERSONS BY INDUSTRIAL SECTOR IN GERMANY, 1977 to 1990

	Econ. active persons in 1'000		1990 compared to 1977		Econ. active persons percentage share of total	
	1977	1990	in 1'000	in %	1977	1990
1+2 Agriculture and forestry	1'656	1'415	-241	-14.6	6.6	5.7
3 Electricity, gas, water	233	298	65	27.9	0.9	1.2
4+5 Mining and quarrying	240	225	-15	-6.3	1.0	0.9
6 Chemical industry and refineries	600	555	-45	-7.5	2.4	2.2
7 Rubber and plastic products	286	297	11	3.8	1.1	1.2
8 Manufacture of cement, lime and plaster	183	158	-25	-13.7	0.7	0.6
9 Pottery, china, earthenware and glass	134	104	-30	-22.4	0.5	0.4
10 Basic metal industries	433	365	-68	-15.7	1.7	1.5
11 Foundries	118	91	-27	-22.9	0.5	0.4
12 Steel construction	170	159	-11	-6.5	0.7	0.5
13 Non-electrical machinery, manuf. of office, computing and accounting machinery	1'044	1'219	175	16.8	4.2	4.9
14 Motor vehicle manuf.	654	725	71	10.9	2.6	2.9
15 Shipbuilding and aircraft manufacturing	111	115	4	3.6	0.4	0.5
16 Electrical machinery	955	1'300	345	36.1	3.8	5.2
17 Manuf. of precision instruments	138	142	4	2.9	0.8	0.6
18 Cutlery, hand tools and general hardware	310	318	8	2.6	1.2	1.3
19 Furniture and fixtures primarily of metal	122	108	-14	-11.5	0.5	0.4
20 Music, games and sports equipt.	61	48	-13	-21.3	0.2	0.2
21 Wood and wood products	259	269	10	3.9	1.0	1.1
22 Paper and paper products	164	138	-26	-15.9	0.7	0.6
23 Printing and publishing	170	124	-46	-27.1	0.7	0.5
24 Leather products	87	61	-26	-29.9	0.3	0.2
25 Manufacture of textiles	328	259	-69	-21.0	1.3	1.0
26 Manuf. of clothing	256	194	-62	-24.2	1.0	0.8
27-29 Food, beverages and tobacco	441	453	12	2.7	1.8	1.8
30-31 Building and construction	1'697	1'288	-409	-24.1	6.8	5.8
32 Wholesale, retail trade	3'156	2'813	-313	-9.9	12.7	11.4
33 Communications	469	518	79	16.8	1.9	2.2
34-35 Transport and storage	942	754	-188	-20.0	0.8	0.0
37 Banking	491	510	19	3.9	2.0	2.0
38 Insurance	199	172	-27	-13.5	0.8	0.7
39 Restaurants and hotels	677	695	18	2.7	2.7	2.8
40-47 Other services	1'805	2'219	414	22.9	7.2	8.9
48-49 Private households, non-profit profit organisations	708	765	57	8.1	2.8	3.1
50 Public authorities	3'576	4'018	442	12.4	14.3	16.1
51 Others(1)	2'048	2'040	-8	-0.4	8.2	8.2

1. Essentially small-scale manufacturing business.

Source: Technischer Fortschritt - Auswirkungen auf Wirtschaft und Arbeitsmarkt, opt. cit., p. 138.

The Irish view as detailed in Table 33 neatly shows how the interaction of productivity increase and output changes generate the employment effect. From the table we see that in the Irish situation, the major employment growth sectors will be chemicals and electronics, with lesser contributions from services, construction, engineering and food. The major losing sectors will be agriculture and clothing. What is particularly fascinating from this Table is that comparing the forecasts for the next decade relative to the outcome from the past two, the effect of microelectronics is to, if anything, reinforce past trends rather than reverse them.

3.1.4. By age and sex

"The adverse employment effects of technological change tend to fall disproportionately on particular groups in the community (women, youth, immigrants, and the aged) and the beneficial effects are best able to be enjoyed by other groups."

This Australian statement is reflected in many of the reports.

As far as women are concerned, it would seem that data processing initially threatened male rather than female qualifications (process control, in particular), while women tended to predominate in lower level information occupations. During the period of massive microelectronics utilisation which is now commencing, it would seem on the contrary that it is the jobs held mainly by women which will be the most directly affected by computerisation (secretarial work in particular), while at the same time the numbers employed in data acquisition - 90 per cent of whom are women - are declining (Jandon and Zarader, 1981). To gain an accurate idea of the problem that this poses, it should be remembered that in many developed countries women have accounted in the recent past for almost 80 per cent of net job creation.

Concerning youth, the United Kingdom report states the view in its own way:

"any reduction in manpower ... will largely be achieved by natural wastage. The jobs that will be wasted will tend to be relatively low in skill content and this will mean that the brunt if any, will largely be borne by school leavers or would-be entrants to the labour market looking for jobs with a relatively low skill content ... new technology

Table 33
OVERALL ASSESSMENT OF SECTORAL PROSPECTS 1980-1990 - IRELAND

Sector	Trend in Employment 1960-1980	Productivity gains from expected use of micro-electronics 1980-1990	Market potential for increased output 1980-1990	Employment trend 1980-1990	Notes
Agriculture	↓ ↓	*	++	↓ ↓	
Food	↓	+	++	↑	Structural changes could improve prospects
Drink and tobacco	↓	*	*	↓	
Chemicals	↑	+	++	↑ ↑	
Engineering	↑	+	+	↑	Increased level of R & D Marketing would lead to greatly improved performance
Electronics	↑ ↑	++	++	↑ ↑	
Printing/Paper	↓	++	+	↓	Industrial Relations difficulties will prevent productivity gains from being realised
Textiles	↓	+	+	↓	
Clothing, etc.	↓	*	-	↓ ↓	Survival will require more emphasis on high quality output for specialised markets
Construction	↑	*	+	↑	
Transport, Communications and Storage	↓	*	*	↓	
Commercial Services	↓	*	+	↑	
Personal Services	↓	*	*	↓	Trends towards increased leisure may alter prospects in the late 1980s
Recreational Services	↓	*	*	↓	
Professional Services	↑	+	++	↑	Particularly software and information services
Financial Services	↑ ↑	++	++	↑	
Public administration and Defence	↑	*	*	↑	Strong pressure to moderate employment trend
Utilities	↓	*	*	↓	
Mining, etc.	↓	*	*	↓	

Key to symbols:

↑ Moderate increase
↑ ↑ Substantial increase
↓ Approximately static
↓ Moderate decrease

↓ ↓ Substantial decrease
+ Positive
++ Very positive
* Negligible
- Declining

Source: Microelectronics, The Implications for Ireland, Vol. I, op. cit., p. 75.

is likely to have the effect of reducing job opportunities for school leavers who lack basic skills of numeracy and literacy."

This concern for the young is reflected elsewhere.

3.2. LABOUR SUPPLY - PROSPECTS FOR THE 1980s

In Table 34 we detail some ILO predictions on labour force growth in a number of countries. These must be considered very speculative, and also differ from those discussed and used above due to different methods and definitions used in the construction of the series. We would also expect to see by extrapolating from past trends:

- a) reducing length of the working week;
- b) increasing female participation;
- c) increasing supply of part-time labour;
- d) increased levels of educational attainment among the labour force.

Subject to certain reservations, it may be argued that the impact of microelectronics on the demand for labour is, if not identical, at least similar in the main developed countries. This being the case, it is the circumstances surrounding the supply of labour which vary considerably from one economy to another, that will cause the overall effects of microelectronics on unemployment to differ very markedly. Given this it seems appropriate to consider labour supply in some more detail. It is convenient to consider the case of France.

1. General

Demographic trends have a decisive influence on the volume and structure of the population of working age. Even assuming stable participation rates, it is probable that about 200,000 people joined the French labour force each year 1975-1980, net of migration (VIII Plan, 1980). This indicates the continuation of an upward trend that began in the early 1950s. It is an increase that not only reflects the increase in arrivals on the labour market as opposed to departures, it also reflects the big postwar generations that are now coming onto the labour market. Taking migration into account has only a marginal effect on the overall trend. Looking at the medium-term estimates (1980-1985), it is clear that recent trends will probably continue (net migration nil, working population up 182,000 per year), with demographic pressure only beginning to ease from the second half of the 1980s.

Table 34

LABOUR FORCE PROJECTIONS 1980-85

	% increase
Germany	5.1
France	6.3
Netherlands	5.4
Belgium	3.9
Austria	5.2
Italy	3.8
United Kingdom	3.0
Sweden	3.0
Denmark	3.3
Finland	2.9
Norway	3.0
Ireland	5.8
United States	6.0
Canada	8.1
Australia	8.4
New Zealand	7.6

Source: ILO, Labour Force Projections 1950-2000,
Vol. IV, Geneva, 1977, Table IV.

2. Skill Structure

The structure of the labour supply depends very largely on how the training system develops. Over the period 1952-1974 there was an almost continuous increase in flows of school-leavers. Similarly, there has been a rapid rise in the numbers enrolled in occupational training course (2.1 million in 1972 compared with 2.7 million in 1978), even though here there was a slight downturn at the end of the period.

The training problem is not solely quantitative however. Adapting the economy to new growth conditions depends on the training-employment match, and here there is still much to be done. To take only the case of the information occupations, there is a twofold example of mismatching (V. Muldur and R. Zurader, 1980). On the basis of forecast requirements in this field, it is already obvious that there are serious deficiencies as regards initial government training for information technicians, the only solution for the moment being on-the-job training(8). The shortage, which can be put at 15,000 people in 1979, can be expected to grow and represent a shortfall of 82,000 technicians over the period 1980-1985 (J. Tebeka, 1980). Yet this shortage is all the more noticeable because some information training does not seem to match employers requirements. This is the case, for example, of certificates (certificats d'aptitude professionnelle - CAP) in information processing, unemployment rates being close to 50 per cent in respect of these qualifications. While it is not possible to discuss the subject in detail, the few studies now available show clearly that adapting the labour force to technological developments necessarily involves the training system. Given that the time that elapses from the decision to set up a training scheme to the arrival on the labour market of the first to complete the course can exceed 15 years, it may be appreciated that training will be an essential factor in the future - whether looked at in the short, medium or long term.

3. Age and sex

Participation rates have followed two contradictory trends, the overall effect of which has been to accentuate the demographic pattern.

Participation rates have fallen at the age extremes; among young people aged under 24, for example,

1. Private schools, manufacturers and software houses provided training for only 3,200 technicians in 1979.

the participation rate declined from 66.6 per cent in 1962 to 52.5 per cent in 1979. The main reason for this is the later school-leaving age which rising unemployment has obviously encouraged. Among people aged over 55, participation rates dropped during the same period from 54.7 per cent to 32.7 per cent, the cause being mainly to do with labour legislation which has encouraged retirement.

Offsetting these effects, however, female employment during the same period grew massively, this being based on profound changes in society and growing stronger from one generation to the next. In view of the unequal numbers involved, the outcome of these two trends alone is that the working population grew by an average of 40,000 people per year over the period 1975-1980.

For the years 1980-1985, the forecasts suggest that participation rates among women aged between 25 and 55 will rise (+ 94,000 per year), while they will stabilize among the more elderly (- 80,000 per year).

Adding these estimates to demographic trends gives an increase in the working population in excess of 200,000 people per annum over the period 1980-1985.

On the basis of this figure, the question of the social consequences of microelectronics appears in a new light. If, as a result of this sort of technical progress, it is assumed that demand for labour will stabilize, it becomes immediately apparent that labour supply trends will mean one million more unemployed by 1985. Although this type of reasoning, which is on an "all other things being equal" basis, does not allow any definitive conclusions to be reached concerning the impact of microelectronics on unemployment, it does, however, give some idea of the scale of the problems.

3.3. THE BALANCE OF SUPPLY AND DEMAND IN THE 1980s

By looking at the balance of supply and demand for labour we aim to make some observations on the future time path of unemployment. In the sections immediately above where we have considered a number of economic models and less strictly formal studies for different countries we have already begun this exercise. A brief summary of these results is that:

- i) microelectronics will lead to a changed structure of skill demands, the least qualified suffering the greatest loss of job opportunities;

- ii) microelectronics will induce different patterns of industrial structures thus necessitating a certain mobility of the labour force;
- iii) compensation effects will offset some, if not all, the direct effects of microelectronics on aggregate labour demand.

The results suggest that, if the rate of growth of world trade is not affected and because of microelectronics an economy has productivity 10 percentage points higher in 1990 than it would have had (and if it has not advanced technologically faster or slower than its competitors), then aggregate labour demand will be somewhere between 0 and 4 percentage points below what it would have been had microelectronics not occurred. The conditionality of this statement should be noted. The productivity figure for example means that during the 80s the trend rate of growth of productivity is considerably higher than in the second half of the 1970s. Microelectronics is not only assumed to increase productivity but also to permanently raise the rate of growth of productivity. Moreover in this statement the use of microelectronics is assumed to not affect the rate of growth of world trade. This seems unlikely - the development of new products alone would stimulate it. Our considered opinion is that a figure closer to the optimistic prediction is most appropriate.

However consider further the impact when a country develops at a rate different from that of its competitors. All the reports suggest that slow progress has a much worse outcome, whereas fast progress can yield compensation effects in excess of 100 per cent. Obviously not all countries can proceed faster than their rivals, so not every country can "export unemployment". It may be that developed nations gain at the expense of developing countries or that if one country gains or loses significantly then this will lead to a wave of protectionism. However given the gain to be derived from fast progress, a fast diffusion rate across the world would seem likely. This may well have expansionary effects on world trade with beneficial effects for all.

As not all countries can be relatively fast let us assume that all countries proceed at the same rate. Then aggregate labour demand, we suggest, will be 0-4 percentage points lower in individual economies by 1990 on the assumptions above. Let us now combine this with labour supply details. In the previous section we suggested that labour supply for demographic reasons will have its fastest growth to 1985 after which labour supply growth will begin to fall. Our reasoning

suggests that in general, unless an economy is proceeding faster than rivals, new technology will not make any significant contribution to meeting growing labour supply targets especially to 1985. We can not expect, therefore, a reduction in the generally high unemployment levels in the developed world through the use of these new technologies.

Will the new technology make unemployment worse? Our range of predictions, 0-4 percentage points reduction in labour demand in the absence of induced changes in the level of world trade, suggest that it may. This however results from an assumption that trend productivity growth will rise by about 25 per cent or more which is a considerable change. Moreover, to put the 0-4 percentage points in context, a reduction in the length of the working week from 40 hours to 39 hours would reduce labour supply by $2\frac{1}{2}$ per cent which is quite sufficient to more than offset the mid point of the range of estimates, the optimistic end of which we are inclined to support. Given this view we are inclined to suggest that the problem of balancing labour supply and demand at the aggregate will not be exacerbated to any great extent by the new technology.

Let us turn now to skills. If we take the German estimates in Table 30, the figures suggest that by 1990 approximately $7\frac{1}{2}$ per cent of the jobs that existed in 1977 will no longer exist, but because of almost complete compensation another $7\frac{1}{2}$ per cent of jobs will be created. The new jobs will require more and/or different skills. This suggests that in the absence of a supply of these skills we can see a much more considerable impact on unemployment than we were finding in the aggregate. We have already indicated that in France it is suggested that there is a shortfall of information technicians and in the United Kingdom report it is suggested that there will be shortages of microelectronic and computer related skills. It appears to us that there will therefore be considerable retraining requirements if full employment is to be guaranteed. Even if one argues that some of the jobs lost will go through people leaving the labour force, then there will still be some who must be retrained and new entrants to the labour market will require skills they would not otherwise have required. Unskilled new entrants will find fewer job vacancies, this will tend to affect women and the unskilled young particularly. The older worker whose skills become redundant may also suffer particularly relative to a new young entrant who may be more trainable. Thus not only does the large shift in skill requirements indicate that major training and retraining schemes will be necessary, but it also suggests that unskilled new entrants, the older worker and women may suffer particularly, and unemployment may well be concentrated in these categories.

The training requirements are not purely a matter of educational attainment however. The Dutch analysis suggests that highly educated personnel will be in excess supplies, for the demand is not for education per se but for job related skills - and these are not the same.

Overall, therefore, we see the main problems arising because of the different structures of labour demand and supply rather than because of an overall shortage of jobs, although the latter problem could be important for some countries because of the rate at which their labour force is expected to grow.

4. WORK CONDITIONS AND THE PRODUCTION PROCESS

A number of the reports discuss the possible impact of new technology on work conditions and the production process.

"The best-known and perhaps most typical consequences of information technology are the great improvements which automation has brought about in the process industries. Great reductions have occurred in both the amount of heavy work and the effects of dust, heat, gas etc." (p. 36, Norway)

Automation has also led to a reduced use of shift work in many firms, although an increase in some, the net effect being unclear. The increasing use of visual display units (VDU's) however may lead to visual and mental strain and much VDU work is monotonous and unrewarding.

However, an improvement in physical working conditions can sometimes be accompanied by a deterioration in psychological working conditions. The reason for this is to be found in the increased responsibility attached to jobs with physical action being called for less and less frequently.

On the negative side it is also argued that new technology leads to an increasing division of labour, which may create, especially at lower levels, many meaningless jobs. This leads on to the polarisation hypothesis described above. Moreover with the new technology the formalisation of work (data discipline) is increased. The more advanced the computer system the more programmed the work, reducing job satisfaction and also weakening the negotiating position of individual workers - the more programmed the task the less job specific is the worker's knowledge.

It is also suggested that the effect of the new technology in specialising knowledge higher up the organisation may reduce internal promotion prospects. The nature of information technology it is argued will lead to reduced personal contact because of the increased

division of labour and replacement of person-to-person communication by machine based communication.

Finally Information technology also enables better control for managers with tighter control over individual worker's behaviour and their achievements, with, often, work being controlled by machines, i.e. technology promotes the principles of Taylorism. There is also the possibility of reduced worker influence on management decisions.

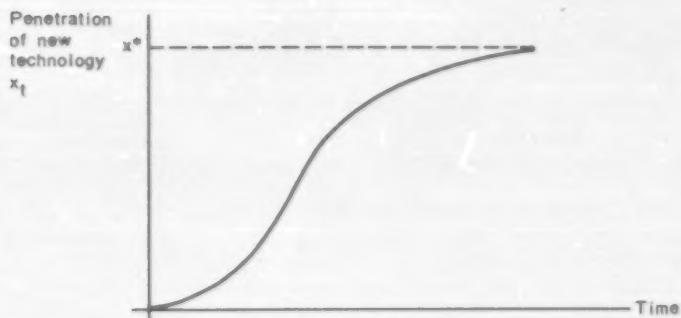
These arguments must however be considered in the light of the opinion that, perhaps more than any other type of technical progress, microelectronics presents an opportunity to improve work organisation. The design of microelectronic equipment does not have to be such as to lead to any deterioration in the nature of the production process. Microelectronics represents an opportunity to improve the quality of working life. Whether this opportunity will be grasped is another matter.

In addition to the quality of working life, the Dutch report also considers the wider questions of privacy and freedom with improved information technology, laying perhaps more stress on impacts outside the work place. However perhaps their conclusion that a clear need exists for information which is as objective as possible about the social consequences of technical development, is the safest possible.

5. FACTORS AFFECTING THE SPREAD OF NEW TECHNOLOGIES

From the work above it is clear that the impact of microelectronics will depend upon the extent of its use in the economy and the speed at which the economy accepts the technology. Conceptually we may think of the transition process in terms of the sigmoid diffusion curve so common in diffusion studies. In Figure 1 we show such a curve.

Figure 1
A DIFFUSION CURVE



The diffusion process concerns changes in the extent of "penetration" over time. We will not detail the measurement of "penetration", but referring to Figure 1 the limit of the curve, x^* , may be considered as the "post diffusion" level of use and the process of approaching x^* as the diffusion process. We may consider that x^* may change over time and we then ask what determines x^* and what determines the rate of approach to x^* (the diffusion speed proper). There is a growing literature on these problems covering many

fields of the social sciences, [see e.g. Rogers (1960) for an early summary] but we do not have space to detail it here. We will however consider what factors have been identified in the reports.

5.1. EXPERIENCE IN THE 1970s

5.1.1. The post-diffusion level of use

Two major studies of the spread of computer use in the United States [Chow (1960)] and the United Kingdom [Stoneman (1976)] consider that the post diffusion level of use is essentially related to the economy's output and computer prices. This is the common argument. It is factor prices that will determine the extent of use of a given technology, for a given output. This is sometimes forgotten. There seems however to be a growing realisation in the reports and in general commentary, that not all the electronic technology discussed is capable of profitable application at the present time.

To concentrate solely on such economic factors is however misleading. The organisation of society and its attitudes can have considerable impact on the extent of acceptance of new technology. It is often argued in the United Kingdom, for example, that the Japanese social structure makes new technology more acceptable than in the United Kingdom. Similarly, different attitudes in different societies as to the right of access to information can considerably affect the final level of use. Simple factors such as the nature of the tax system can also affect final usage. We must also of course realise that the industrial structure will affect the level of use, for example, in the early and perhaps late 1970s computers were mainly used for administrative and office purposes and thus the extent of use would depend on the size of the information sector.

In addition, among other factors, general streams of thought emerging in the course of economic and socio-political development affect the acceptability of new technologies in our modern pluralistic societies(1). In the Austrian study(2) the authors tried to elaborate four scenarios reflecting alternative basic conditions on the economic as well as on the socio-political plane. In Table 35 the scenarios and their most important implications for technological change are summarised. It is clear that such overall pictures of types of economic and socio-political conditions imply a great degree of simplification, but they at the same time make clear that a discussion of the topic of this section would be incomplete if these larger aspects were overlooked.

5.1.2. Determinants of the diffusion speed

The literature details a number of factors affecting the speed of diffusion such as information, profitability, uncertainty, management attitudes, supply factors, the distance into the diffusion process etc. The fact that electronic based technologies have diffused in the 1970s does not really need illustrating. The factors affecting the speed of this diffusion are however numerous. Rada details certain constraints on diffusion:

- a) an inadequate telecommunications infrastructure;
- b) the "dragging" effect of old equipment;
- c) legal problems;
- d) the labour displacing effect;
- e) ignorance of technology and its potential use.

To these Northcott (1980) considers a number of extra factors which seem to be impeding firms from using microprocessors in the United Kingdom:

- f) the poor economic climate, high energy prices and high interest rates;
- g) high development costs;
- h) high production costs;
- i) lack of technical expertise;
- j) supply constraints on chips;
- k) a lack of suitable input-output devices;
- l) the cost of software;
- m) teething troubles and lack of experience in maintenance;
- n) management (not union) attitudes.

However on the positive side a number of favourable factors seem to be operating:

- o) government policies;
- p) cost reductions;
- q) the flexibility of microprocessors;
- r) the improvements in product performance possible;
- s) the new markets that microprocessors open up;
- t) competitive pressure forcing the use of microprocessors.

The Lund (1979) report considered high energy prices as a stimulus to use, with the improved performance of microprocessor based products a key factor in stimulating use. The New Zealand report considers that factors affecting use were in order of importance,

1. For a treatment of some of these aspects see Stolz (1982).

2. Anwendungen, Verbreitung und Auswirkungen der Mikroelektronik in Oesterreich, op. cit., pp. 160-4.

capital availability, a perceived need, the size of the company and its geographic location, and the industry in which it was engaged.

The authors of the main report on the Federal Republic of Germany presented above, note the great importance of the underlying social conditions for the implementation of technological change. The general economic framework used to produce their results, presented above, displays the following broad characteristics:

- Since 1970 changing economic factors have had a major influence upon the rate of implementation of new technology in the economy.
- There are significant shifts in German society's needs and demands. Noteable, especially, are a declining population and a static number of private households reducing consumer expenditure growth and the need for infrastructure, as well as a high level of wealth attained in private and public sectors reducing or changing qualitatively the demand for consumer durables and investment in plant and equipment.
- Growing opportunities arise on new markets originating from increased leisure time and disposable income, scarcity of energy and raw materials as well as the necessities of environmental protection and the growing recognition of the improvement of the working environment as a key to social progress.
- Due to the increasing level of labour specialisation the quality and volumes of community information is of growing importance. This leads to growing markets for professional services and related products.
- Regulations in the fields of environmental protection, safety, health and consumer protection often increase costs, but they at some time may encourage the development of new technical solutions which may open up new markets.
- Competition has intensified at home as well as abroad. The need for innovation is very great. Rapid product and process innovation appear to be the only way to gain access to new, and to consolidated old markets. Innovation is also needed to reduce the cost-impact of inflation.

On the socio-political plane the authors of the German study stress, among other things, that the following factors affect the implementation of technological change:

- Social and organisational conditions in the Federal Republic of Germany which only change slowly.

- Technology-related organisational problems are important. The authors think in particular that the viability of organisations depends increasingly on self-regulating systems that are capable of dealing with conflicts in a co-operative and innovative manner. Further decentralisation of enterprises is believed to be important. Therefore, the availability of interactive and co-operative management systems may help the solution of industrial conflicts.
- The educational system is of decisive importance for the further development of the economy. Employers appear to demand less specialised education but more willingness and ability to learn and to adapt to rapidly changing conditions on the part of employees.
- Employees with high professional qualifications determine more and more the readiness of enterprises to innovate. At the same time they are thought of as having a general influence on the choice of political alternatives.

A relevant general statement in the German study is

"The ability of the social system to cope with the changes arising from technological innovation, and from structural change in the economy, depends on the relationship between the magnitude of the need for adaptation (pressures) and the social degree of freedom to adapt (by a process of self-regulation)."

The problems of adaptation to change in a sector of economic activity are higher:

- the greater the technological feasibility and economic necessity for reshaping existing practices (innovative pressure);
- the greater the attendant need for retraining and new work experience;
- the greater the associated fall in influence of groups of employees that previously played an important role, both within their enterprises and in related external organisations.

On the other hand, the ability of an organisation to absorb changes without disruption is greater:

- the lower the level of concentration of jobs at a regional and company level;
- the greater the level of corporate identity (which decreases with increasing size of the enterprise and increasing complexity in the hierarchy of its organisational structure);

Table 35
FOUR SCENARIOS OF ECONOMIC AND SOCIO-POLITICAL CONDITIONS
AFFECTING MICROELECTRONIC TECHNOLOGICAL CHANGE

		Economic Conditions	
		Favourable	Unfavourable
Socio-political Basic Attitudes	Technocratic	Economic growth is important. Dichotomy between a competitive elite and a hedonistic mass oriented towards consumption. Large scope for microelectronics: Growing markets for sophisticated toys and games. Telecommunication heavily affects media. Large markets for microelectronics in household goods, production equipment and administration and medical equipment. Commercialisation of highly specialised professional education. Collective supply of educational and cultural programmes for the mass of population.	Economic aspirations are less often satisfied. Increased instability of society and economy. Militant "anti" groups emerge. Scope for microelectronics: Markets shifts towards energy saving and security systems. Microelectronics is especially likely to be applied in goods and services facilitating decentralised private activity as well as the decentralised provision of collective goods (e.g. health).
	Participatory	Citizens inclined towards more individual and social responsibility. "Human" work conditions are preferred even at the cost of economic efficiency. Microelectronic applications favouring these values are growing important in the organisation of work. Private and public transport systems display a growing content of microelectronic technology. The same opportunities arise in environment protection.	Decentralised and "democratic" decision making reduces the danger of increased instability in society and economy. Economic conditions reduce the scope for microelectronic technological change. Labour intensive production processes increase in importance. The degree of private supply of informational and educational goods is reduced. Microelectronic equipment favouring decentralised decision processes is preferred.

Summary based on "Anwendungen, Verarbeitung und Auswirkungen der Mikroelektronik in Österreich", op. cit., pp. 160-".

- the more evenly the bargaining power is balanced between all the groups involved, both inside and outside the enterprise. (p. 13)

In the past, Germany has benefitted from a favourable relationship between the need for change and the degree of freedom to implement change for several reasons. The same picture, according to the authors of the German study, will not hold in the future. Therefore, the need for special government action arises.

In Table 36 we detail some results from de Melto (1980), on the factors affecting the decision to innovate by Canadian firms in five Canadian industries. The factors being considered are similar to those discussed above. The advantage of the Canadian Table is that it does give some idea of the relative importance of at least all the different economic factors quoted above. (Given that the labour market impact will depend on whether new technology is used to decrease costs or increase output, these figures suggest that labour market effects may not be too severe.)

Table 36

FACTORS AFFECTING THE DECISION TO INNOVATE - CANADA
(% of innovations)

Factor	%
Response to foreign competitors	12
Response to domestic competitors	11
To take advantage of technological capabilities	57
To reduce labour requirements	10
To reduce energy requirements	7
To reduce capital requirements	5
To meet government regulations	5
Perception of new market	54
As a result of pressure on profit margins	9
To improve product quality	22
Interaction with customers	31
Interaction with suppliers	2
To gain a larger market share	33

Source: de Melto et al (1980).

On the question of the effect of the labour market on diffusion we can turn to the United Kingdom report. There have, of course, been good examples (e.g. The Times) of labour force resistance slowing down technological change but it seems that this has not been a general problem. The United Kingdom report also considers that so far skill constraints have not been a problem. It considers, however, that labour force resistance can be a constraint on diffusion and advises consultation between management and the workforce and no redundancy agreements as a way round this. In fact the attitude of most trade unions (e.g. see the reports of New Zealand, France and the United Kingdom) is that new technology should not be resisted, but safeguards must be provided for jobs prior to its introduction, and moreover there should be benefit to the workforce in terms of wages as well as to profits.

To give some idea of the time profile we are discussing, in Stoneman (1976) some estimates of the diffusion speed of the spread of computers are made. Fitting a Compertz curve:

$$\frac{d \log x}{dt} = g \left(\log x^* - \log x \right)$$

to data on the spread of computer usage, an estimate of g of 0.23 is derived. This estimate implies that it would take the economy 23 and a half years to go from usage equal to 10 per cent of x^* to usage equalling 90 per cent of x^* . This figure differs considerably from the ideas implicit in many stories told by those who forecast heavy unemployment.

To summarise, numerous factors affect diffusion speed, some economic, some environmental, but the main point to make is that diffusion is a slow process and this ought to be held in mind when considering the impact of microelectronics.

5.2. PROSPECTS IN THE 1980s

We do not think there is any doubt that micro-electronic technology will continue to advance. The price/performance ratio of the products will continue to increase as will storage capacity, logic capabilities and speeds. However perhaps these hardware characteristics will not be as important as software improvements. The hardware already seems to contribute only a minor proportion of total costs in any application, but

software seems to be more of a constraint. As more high level language compilers are available, for example, so microprocessors will be of greater applicability. It also seems clear that new uses for old products and new products incorporating microelectronics will become available.

The major concern for the 1980s however will not be the further extension of microelectronic capabilities, but more the application of what is already available. We have discussed above the various factors which will influence the diffusion speed. What we can do here is give some idea of the forecasts contained in the national reports. In the United Kingdom report it is considered that the process of penetration of a new technology in industry is generally an evolutionary rather than a revolutionary one, and microelectronics technology is unlikely to provide an exception. Norway state that the diffusion of information technology will proceed more slowly than one might imagine.

The Dutch quantify their predictions by suggesting a growth in the number of processors in the Dutch economy by a factor of 4-5 by 1990. The world computer stock (by Rada's figures) grew by a factor of 4 between 1970-1978 and these figures thus suggest that diffusion will be at the same sort of speed as in the past. If one can provide a summary, it is that past experience will be repeated, and thus the effects to be expected will not differ much from those of the 1970s.

The forecasters do see, however, some possible major differences between the experience of the 1970s and the 1980s.

1. In the event of a failure to generate sufficient skilled personnel, they see diffusion slowed down by a lack of appropriately trained engineers.
2. In the event of large-scale unemployment they see increasing resistance to new technology on the part of labour, and
3. They see increasing concern with the effects of microelectronic technology on society, work conditions etc. that may affect either the speed or direction of the application of technology.
4. Finally, it is accepted that the rate of diffusion in one country cannot deviate too far from that in other countries without unacceptable consequences. The rest of the world may therefore be forced to follow the fastest.

6. GOVERNMENT STRATEGIES AND POLICIES TOWARDS ELECTRONIC BASED TECHNOLOGIES

6.1 GENERAL PROGRAMMES

Governments declare their economic objectives as high employment, low inflation, high growth and external balance. They have attitudes towards equity, health care, educational attainment and wish to "offer members of society the conditions to which, according to modern views, everyone is entitled" (Rathenau Report, p. 11). In pursuit of these numerous and often conflicting objectives programmes of subsidy, taxation and expenditure are set up. Each of these programmes may have some relevance to the general microelectronic question. It is however impossible to detail such programmes here. Thus, for example, purely at the macro level, most governments have programmes of investment subsidies, planning policies, employment subsidies, tax offsets, regional policies and R & D subsidisation programmes that are generally aimed at generating higher investment, higher productivity and full employment. The diffusion and impact of electronic technology in the past is likely to have been affected by all such programmes.

6.2. SPECIFIC PROGRAMMES

If we turn to specific programmes aimed at electronic based technologies we can gain some insight as to the extent of government involvement in this area by considering the extent of government support for national computer industries. Between 1972 and 1975, the United Kingdom government support (to ICL) was approximately £30 million, France provided £72 million and Germany £93 million for computers and peripheral development. It is estimated that between 1978 and 1983 the United States government will support electronics R & D to the extent of £200-£400 million (excluding military based expenditures). The Japanese were supporting very large scale integration development over

the period 1976-79 with £300 Million. Further current subsidies exist in the United Kingdom. INMOS is being government funded up to £50 million, and the office equipment sister, NEXOS was also being encouraged. Further funds in the United Kingdom are provided to support MAP, the microprocessor awareness programme there is support for R & D, CAD/CAM awareness programmes, plans for information technology and microsystem centres and demonstration projects. The Dutch have decided to start a programme of encouraging industry and providing scientific and technical backup for microelectronics users involving 38 million guilders in 1981.

In France, government policy has embraced several aims. Special efforts have been made with regard to research - via the INRIA (Institut national de recherche d'informatique et d'automatique) in particular, and financial assistance provided by the DGRST (Délégation générale à la recherche scientifique et technique). In the strictly industrial field, the CODIS has had the task of seeking out dynamic industrial enterprises determined to take certain risks in strategic openings, and then giving support to the selected enterprises. Temporary and limited government assistance in this area has taken the form of development contracts between the Government and the enterprises concerned.

This policy of developing microelectronics has also been furthered by three public bodies:

- the DIELI, which is responsible for industrial matters in the electronics and data processing sectors;
- the Mission à l'informatique, whose task it is to consider the consequences of computerisation; and
- the Agence pour le Développement de l'Informatique, which promotes and provides information about microelectronics among enterprises.

In addition to direct subsidies and, often, tariff barriers, it has been common practice in the past for governments to use their purchasing policy to support their home computer industries. It is now intended that government purchasing should also be used to stimulate microelectronic use and development. The Norwegians are evaluating state procurement as an instrument of developing Norway's know-how. It is interesting however, that whereas in the past, especially in the United Kingdom, government policies and subsidies have been biased towards the equipment manufacturers, current emphasis with microelectronics is very much towards stimulating use. Most countries however are willing through subsidisation to attract foreign suppliers to

set up manufacturing facilities in their domestic economy, even if they are not encouraging the development of a domestic supplier.

6.3. ALLEVIATING LABOUR MARKET EFFECTS

Many countries have existing programmes that are aimed at alleviating the effects of unemployment. Unemployment insurance and redundancy payments schemes are common. The Australian report states that it reviewed 300 policies and programmes that already relate to this area. In very few cases however are these policies particularly aimed at or tailored for microelectronic induced changes.

In France a number of organisations have, however, been set up with the object of defining a policy in this field. The Agence pour le Développement de l'Informatique, for example, devotes 10 per cent of its budget to training activities. The Mission à l'Informatique, in co-operation with the Ministry of Labour, is responsible for having drawn up a "Plan Informatique et Conditions de Travail", the purpose of which is to ensure that the social dimension is built into government policy concerning microelectronics.

The Norwegians seem to be in a somewhat unique position with regard to their Data Agreement and the relevant provisions of their Working Environment Act as detailed in OECD (1981), pp. 222-239. Here we have an attempt to minimise the required government action by ensuring appropriate consultation prior to the introduction of new technology. It is of course a policy aimed more at the quality of the working environment rather than unemployment but as we have argued above the labour market implications in this area are just as important.

It is noteworthy that in general governments have relied upon existing policies and programmes to cope with the implications of microelectronics. As we have argued above, it may not be the man made redundant by the introduction of microelectronics about whom one must worry most, it is more the man whose job is destroyed by a failure to innovate that is the real casualty, and a microelectronic-oriented policy would not be appropriate for such an individual.

Although this is not the place to criticise social policies of Member countries, it is note worthy that in many cases industrial policy is defined without considering the social impact, and social policy is

subordinated to industrial policy. At a time when microelectronics reinforces the complementarity of labour and capital such a separation seems most inappropriate.

6.4. FUTURE PROSPECTS

Certain countries (such as the United Kingdom with INMOS, NEXOS, its MAP scheme, Microelectronics Support Programme and Product and Process Development Scheme) have already begun to stimulate their national economies to search for new products and processes. The Norwegians have declared in their Long Term Programme an intention to create the telecommunications infrastructure necessary to support the microelectronic society, to assess the establishing of foreign R & D activities in Norway, and to assess the use of a few larger trial projects for investigating the possibilities and impacts of the new data technology on Norway. The Dutch have agreed to set up an information and advice centre to which small and medium sized enterprises could apply for help and also wish to encourage the attraction of semiconductor manufacturers to the Netherlands. They have undertaken a number of practical measures such as an advisory scheme, information provision and a microelectronics credit scheme. For 1981 a programme totalling 81.75 million guilders is detailed.

On the general level the German study is asking for the orientation of research and technology policy towards(1):

- "overcoming problems of communication which can arise between technicians and entrepreneurs, employees and other social groupings, possibly through an improved dialogue about the impact of innovation, close attention to potential social impacts in the course of all planning, fundamental studies of the interrelationship between the social and technological influences in society;
- further support for research to enable technology to better match the community's actual needs (e.g. by emphasising applied technology for the improvement of the environment, recycling, alternative energy supplies, improved working conditions, and by underwriting the risks of product innovation)."

1. Loc. cit., English summary, p. 27.

The Austrian report addresses itself to different problems (pp. 182-3).

- "Microelectronics is considered to deserve a key position within Austrian research and technology policy. Although the authors of the Austrian report do not think that the production of integrated circuits should absorb the greatest amount of attention in Austria, they argue for substantial know-how of production processes, methods of design and tests. The application of microelectronic technology is expected to be helped by increased activity in the area of microtechnics in Austrian universities and other centres of higher education. Research should be directed towards complementary fields like sensors and the like.
- Of considerable importance to the successful exploitation of the opportunities offered by microelectronics is information and the support of applications in small and medium-sized firms (Informationsstelle für MikroelektronikAnwendung)."

In Switzerland practical policy efforts have been going in the direction described by the Austrian authors for a couple of years. A brief description of what is called the "impetus programme" in Switzerland is contained in the 1979 OECD Etudes Economique for Switzerland. (pp. 46-7)

"In December 1978, the Federal Parliament adopted a series of measures to promote technological development and training (the "impetus programme"). The following are the main fields to which this programme applies:

Electronics technology: Government aid is given for:

- quality assessment of electronic components and testing in use;
- training in connection with software;
- a programme of improvement of electronic watch components.

Incentives to practical research and development. As part of the measures to stimulate economic activity that were introduced in 1976, an additional appropriation of Sw. Frs.5 million was made available for one year to facilitate projects for expanding output and developing the techniques of industrial processes. In 1978, the appropriations made under this heading for a four-year period were increased somewhat (Sw.Frs.24 million for the

period 1979-1983), and particular emphasis was placed on one area, namely microprocessing, for which the Swiss authorities consider that applications outside the clock and watchmaking industry should be systematically developed.

Lastly there are measures to facilitate access by heads of firms to data banks, and some provisions for energy saving in construction techniques."

In addition and as a consequence of the structural adaptation problems of the Swiss watchmaking industry, aggravated by the recession years in the second half of the 1970s, a number of measures were taken to provide financial help in regions which are classified as economically threatened. The help is going to individual firms directly and is meant to stimulate the modernisation and diversification of both existing firms and the regions as a whole [by attracting new firms(2)].

The New Zealand report advised assistance to small and medium firms to enable them to maximise the opportunities presented by microelectronics, and recommends a need for co-ordination and mutual support in the electronics industry.

The Australian recommendations are lengthy and detailed but are neatly summarised as that:

"industry uses the high level of expertise in Australia to develop new products and processes and therefore create new employment opportunities ... Industry (must) keep up with world technological advances and where possible try to lead."

The recommendations, with government reactions, include further government support for R & D (accepted in principle) the sponsoring of a private venture capital corporation (referred for further consideration) the establishment of technology and microelectronics awareness programmes (accepted) and a grant for small business employing consultants (not accepted) (the latter being similar to the MAP programme in the United Kingdom), and union reorganisation (accepted in principle).

Finland stresses the need for further R & D support and an increase in technology transfer and high technology imports.

2. See: Bundesbeschluss vom 6. Oktober 1978 über Finanzierungsbeihilfe zugunsten wirtschaftlich bedrohter Regionen.

Ireland is recommending a microelectronics awareness programme, further academic/industrial interchange, encouragement to industry to use their Product & Process Development Scheme, and stimulation of the domestic Information Technology Industries. They also suggest the initiation of pilot projects in the Public Sector.

As can be seen most of these countries have accepted or are recommending considerable government support, in one way or another for the spread of the use of microelectronics. They also all stress the need for further education and training in the area of microelectronics. The Dutch have allocated 25 million guilders to retraining in 1981. Finland recommends that the fundamentals of the new technology be taught to all age groups beginning from lower secondary school. The Australian government has increased its support for monitoring literacy and numeracy. The New Zealand report discusses the need for the allocation of responsibilities on retraining and relocation and the need for changes in education and training. The Irish also stress the need for educational changes.

The main issues in education policy are very well summarised in the German study. Its authors ask for(3):

- "developing the skills of analytical thought and problem solving through teamwork, practical continuing adult education training, providing educational facilities to teach basic qualifications having widespread application, combinations of school education with training on-the-job, some years of industrial experience as a precondition for the training of teachers;
- placing emphasis upon flexibility as a main goal of education, possibly through improved social learning, developing human capability to learn on the basis of practical education matched to society's needs, and through the provision of improved adult education."

The Australian report also goes one stage further by discussing the need to review wage relativities for different skills - an argument based on a principle that if more skills will be required in the future appropriate differentials can encourage their supply.

1. Loc.cit., English summary, p. 27.

6.5. NEED FOR IMPROVEMENT OF EXISTING INSTITUTIONAL STRUCTURES

A review of the conditions determining the employment effects of technological change (and the supporting empirical evidence) led Blattner (1981) to the observation that there is a definite need to improve existing structures and institutional arrangements. The improvements should, when implemented, serve to secure a smoother and less painful process of adaptation in economies and societies as a whole. According to this analysis the critical factors determining the adaptability of an economy to technological change are:

- the responsiveness of investment activity in general;
- market organisation in regulated as well as in non-regulated industries; and
- the rate of adaptation (traditionally slow) of labour supply especially with respect to its qualitative characteristics.

Institutional arrangements and structures affecting these factors will be major influences on the eventual effectiveness of any policy measures undertaken.

6.6. NEW FORMS OF SOCIAL CONTRACT

A common theme of many of the reports is that new technology can yield great benefits. The question is, who receives the benefits and who carries the burden of the costs. In response to this a number of reports are suggesting that a Norwegian type Data Agreement underlies the introduction of information technology so that the people likely to be affected by new technology are informed and consulted. Such a recommendation in the Australian report has been endorsed by their government. The New Zealand report also advocates appropriate consultation procedures. The Australians in fact advocate generating minimum standards on notification, information and consultation. The United Kingdom report considers that information and consultation with the workforce is almost a necessary prerequisite for a successful introduction of new technology.

The Australian report also recommends a social safety net to assist people to adapt to change, with government support for the introduction of a two part retrenchment compensation scheme and a temporary income maintenance scheme. This was not accepted by their

government. The Netherlands have also decided that no such special employment measures are required to date, and the United Kingdom report considers that existing schemes are sufficient.

Finally the reports in general consider that the potential effect of microelectronics on the working environment are important and represent an opportunity that should be grasped to generate improvements. In a similar vein, both the Netherlands and Australia see a need for further legislation on personal privacy in the face of the microelectronics revolution.

This section on government policies and strategies towards electronic based technologies may be brought to an end by once more quoting the German study. Although its authors sketch a relatively favourable picture of the future in terms of the employment impact of micro-electronic technological change, they at the same time clearly see growing conflicts in society. They write:

"... government policy will need to be specifically shaped to counteract what will be an increasing tendency towards conflict in the community."(4)

The solution of social conflicts has always been a major task of government. Technological change appears to accentuate the importance of this task in the future.

1. Loc. cit., p. 25.

7. CONCLUSIONS AND SUMMARY

It is not easy to provide a summary and a set of conclusions to a report that is already a summary of other evidence.

First we must state one or two obvious points that we have already stressed but merit further emphasis. The impact of microelectronics on any individual nation will depend inter alia on:

1. the technological starting point for that economy;
2. the extent of the potential productivity gain to be derived from microelectronics;
3. the time profile for which the forecast is being produced;
4. the trading environment and the behaviour of other economies.

Given these caveats we may argue on the basis of what we have discussed above that to date there is no evidence that technological change has contributed significantly to the current high levels of unemployment. In fact, other factors seem to be more important. However, the effects of technological change on skill demands and supplies have been noticeable.

For the future, the diffusion speed is important and our analysis above suggests that it will be slower than was originally expected. Microelectronics has the potential to radically affect industrial structures, the demand for different skills and certain categories of workers. We have shown however that if the hypothesised compensation effects arise then, in aggregate, the demand for labour should not be affected to any great extent.

We conclude that:

- a) Microelectronics is becoming of increasing importance in all spheres of economic activity.
- b) The changes brought about by microelectronics to 1990 will have greater effect on skill levels and organisation structure than on the aggregate demand for labour.

- c) A low level of application in any individual country may lead to its domestic economy becoming increasingly uncompetitive, and this may in turn lead to secondary effects on employment that could be far more serious than the direct displacement effects.
- d) Microelectronics has the potential to improve the quality of life but given the current situation in each country there is no automatic guarantee that the benefits will be realised.

Microelectronics represents an opportunity for economies to improve both the social well-being of their population as well as on a strictly economic level to improve international competitiveness and living conditions. However the process of generating these benefits will involve costs and these costs ought to be considered in any policy formulation. Government policy should therefore not only be directed at the speed of introduction of microelectronics based technologies, but should also be directed at ameliorating some of its undesirable consequences. At the economic level we see these costs as being mainly related to structural problems (e.g. mismatches of skill demands and supplies in the labour market) and we thus consider that policy should be directed towards making adaptation easier and less costly to the individuals concerned. Moreover, the potential that microelectronics has to improve the quality of life suggests that some direction must be provided to the design of microelectronic based products. The methods of achieving these objectives however will depend more on political philosophies than competing economic theories.

Appendix I

COMPENSATION EFFECTS

Principles of compensation are built on the argument that the introduction of a new technology will not only affect the technical coefficients of the production process but will also of itself and through impacts induced by the changes in these coefficients, affect the optimal input mix and the level and composition of output in the economy. In the reports analysed in the main body of this document the impact of new technology on the level of labour input per unit of output is frequently discussed. Often some qualitative statement is then made as to how the labour force will have to change to use the technology efficiently to produce a given level of output. As is often pointed out, however, this only tells us of what will happen to labour demand if output remains constant, and in general one would not expect it to so remain. It does not therefore provide a good estimate of how new technology will affect labour demand. Similarly, the summation or extrapolation of results based on case study analysis with fixed output assumptions also yield poor indicators because aggregation based on assumptions of either a constant output mix or level could well be inappropriate. The analysis of compensation effects essentially concerns those reactions that invalidate the fixed output assumption.

Consider, initially, a firm introducing a new process technology and allow, for the present, that its output remains constant. The new technology will only be rationally introduced if the services it provides are cheaper than under the previous technology. The change in the relative costs of different services to the firm should lead to a change in its desired mix of inputs. Thus, for example, the Canadian reports detail how as information services become cheaper through new technology so the ratio of information to non-information workers in a firm's labour force change, the former being substituted for the latter. This illustrates two important points.

1. If a service becomes cheaper we expect more of it to be demanded and this may (partially at least) offset reductions in input demands induced through changes in technical coefficients.
2. The impact of new technology may fall on seemingly unrelated occupations as well as (or instead of) on directly related employment.

The moral is that one should not expect that a new technology will be introduced into the firm without producing a number of ripple effects elsewhere within the firm - the organisation and procedures of the firm being, at least in part, technology specific.

The argument above assumes fixed output. In a Keynesian view of the world one might consider that a firm's output is demand constrained, in which case the fixed output assumption may be reasonable. However, even in a demand constrained world it is difficult to justify that every firm's output level is fixed. It is more common to consider that either the output of the whole economy or an industry is constrained. In this case, if new technology means lower prices and/or lower quality adjusted prices one might expect the innovating firm to gain market share (admittedly at the expense of others). If such changes in market share do occur then the innovating firm can offset reduced requirements for labour per unit of output against higher output. The reductions in labour demand will occur in those firms not innovating and thus suffering from reduced market shares. However, even if the innovating firm maintains its output level then at least higher profits will be earned or higher wages paid which will lead to some of the compensation effects we discuss further below.

In the neoclassical economics literature it is more common to consider the output level of the firm to be endogenous, not fixed, and to take prices and factor costs as exogenous to the firm. In this story the firm is not demand constrained and is assumed to be able to buy and sell all it wishes at current prices. In such a world Neary (1981) shows that, in the short run (when only labour is a variable input), technological progress of the process type may reduce the firm's demand for labour at a given real wage if the technological advance is labour saving (in the Hicksian sense) and if the short run elasticity of supply is less than unity. Neither condition is likely to be satisfied in all circumstances, and there is some doubt as to whether the conditions will apply to microelectronics.

Overall, it seems fair to argue that new technology enables a firm to increase its output if only by taking market share from rivals. At the firm level, then, positive compensation effects can be rationalised.

However if industry output is fixed then, as we have argued, the impact of new technology on labour demand may not be felt within the innovating firm but may fall on the employees of non-innovating firms. This could be especially important when the technology is of the new product type, where the new product replaces a previous product (e.g. digital watches vs. traditional watches or pocket calculators vs. slide rules). Such impacts may become doubly important when importers are major participants in a market for then the transfer of jobs between firms may mean a transfer of jobs between countries as well.

Allow now that a number of firms in an industry have become users. As the use of new technology spreads one would expect new products to shift the demand curve and new processes to shift the supply curve. As these shifts take place one would expect total industry sales to increase, even if the whole economy is demand constrained. If the total level of demand in the economy as a whole is constant this industry's gain in sales will be largely at the expense of other industries, and even if demand is not constrained it may be the partial expense of other industries. The location of part of the impact on labour demand may thus again be distant from the innovating source. As an example of how one might expect industry sales to change as new technology is introduced one can note the great increase in the sales of calculators as their price, performance and size has changed over time.

The discussion so far has considered the micro-economy. It is, however, within the macroeconomics literature that compensation effects are analysed most informatively. We find it best to initially assume that the economy is closed. We then classify three types of compensation effects.

- a) technology multiplier effects;
- b) income effects;
- c) price effects, and we consider each separately.

a) Technology multiplier effects

The simplest example of a technology multiplier effect is the required increase in gross investment necessary to install the new technology. To the extent that new technology leads to an increase in gross investment there may be increased employment (for a period) in the production of these capital goods. This is the mechanism relied upon in Stoneman (1976) to show that, in the earlier part of the computerisation process, the introduction of computers led to an increase in labour demand in the United Kingdom. Because gross

investment depends upon the speed at which new technology is introduced, the rate of diffusion will be crucial in determining the time profile of its effects.

Of course, the output of investment goods may not be the only area where technology multiplier effects operate. There may be implications for intermediate demands (in the input-output sense) as well. However, gross investment is a good example. We can also use the example to illustrate that the technology multiplier effect is not necessarily positive. Consider that we have an economy using an old technology, not growing, and thus just expressing a demand for gross investment only equal to replacement demand. The new technology then appears and that new technology requires only a small labour input in capital good production (implying a capital-saving bias). If then the diffusion rate is slow it is possible that the labour required to produce the level of gross investment in the new good does not equal or exceed the amount displaced from producing replacement goods of the old type. To summarise on technology multiplier effects, we can say that they can exist but there is no guarantee that they are positive. Moreover, even if they are positive, they create jobs distant from any directly lost and thus may create a demand for labour with different skills, location or other characteristics.

b) Income Effects

Technological advance creates the potential for lower prices higher profits or higher wages in the economy. These increases in real incomes might be expected to positively affect the level of demand in the economy. Consider first that all the benefit of new technology is reflected in increased profits. If these profits are distributed to shareholders or if they are retained and spent (on investment) then some increase in demand should result. However if the profits are retained and not spent then increases in demand are not going to result (one may think of this as a version of the "realisation" problem). Retained profits are only likely to be invested if expectations are buoyant, and expectations are only likely to be buoyant if demand is high. It may be the case that one gets into a vicious circle. Investment will occur and new jobs be created if demand expectations are buoyant but demand will only increase and thus expectations be buoyant if the investment takes place.

If the gains from new technology are all distributed as higher wages one may get round the "realisation" problem. However higher wages means lower

expected profits and this may imply a slower take up of the new technology (a slower speed of diffusion). The slower speed of diffusion will imply smaller technology multiplier effects.

Thus, on income effects, we may argue that the possibility exists for compensation through increased demand, but there is no guarantee that these effects will be realised or that, if they are, that there will not be reduced compensation elsewhere.

c) Price Effects

The third possibility, not yet discussed, is that the introduction of new technology will mean lower prices. Moreover new products should lead to better price/quality ratios for goods to the consumer. This should mean increased real incomes and higher demand if money incomes are not adversely affected. It has been argued, however, that if layoffs occur before price reductions then real incomes will be adversely affected and demand will not increase.

These three classes of compensation effects above have been discussed in the context of a closed economy. In an open economy context there are a number of other factors to consider. The most often quoted complication is that in an open economy the country that most quickly accepts the new technology gains in competitiveness relative to slow diffusers. The loss in competitiveness by the latter means job losses. However the openness of the economy also has implications for the compensation effects discussed above. With the technology multiplier effect, for example, if the new capital goods are supplied from overseas then one might not expect any compensating jobs gains at home. We may thus argue that an innovating economy can obtain extra compensation through trade and can also internalise other compensation effects whereas the non-innovating economy will not achieve either.

These arguments are usually conducted within the implicit framework of fixed exchange rate regimes. Under such regimes a failure to innovate will be reflected in a worsening of the balance of payments with the innovating economy experiencing an improvement. These changes in the balance of payments will probably have further knock-on effects. Consider the case of a non-innovating economy experiencing a deterioration in its balance of payments. In the long run this imbalance must be corrected. In the absence of exchange rate changes or internal price adjustment this correction must come through deflation, in which case further jobs will be lost. Of course if domestic prices fall

relative to world prices exports may be stimulated and deflation may be avoided. Such price reductions will be dependent on cost reductions which implies that wage costs must be lower. If wage costs are lower then deflation may not be necessary and its consequent unemployment may be avoided. This reflects a trade-off that may exist between wages and unemployment(1), the justification for which we return to below.

If we now consider the non-innovating economy operating in a world with flexible exchange rates rather than fixed rates, one would expect its new position of trading disequilibrium to be reflected in a devaluation of its exchange rate rather than a balance of payments deficit (similarly an innovating economy will experience an upward revaluation). As the exchange rate changes so we expect exports and imports to change and thus employment to change. However as the rate of exchange varies so will the real wage. Thus again we expect to observe a relation between unemployment and the real wage.

The implication of this discussion is that the effects of innovation on employment will depend upon the flexibility of costs and prices in the economy. Specifically, a world with flexible exchange rates implies less unemployment (but lower real wages) than a world with fixed exchange rates. This argument can be carried further. If one argues in a Walrasian manner that all prices are perfectly flexible, reacting to notional excess demands and supplies, then at every moment in time all markets clear, including the labour market. This raises a crucial point in macroeconomic analysis. The impact on an economy of an exogenous shock (the new technology) depends upon how one believes the economy will react to the resulting disequilibrium. If, in a Walrasian manner, it is believed that complete price flexibility exists, then all disequilibria, including that in the labour market, will be immediately removed. However, the price structure will be changed, and especially, although there will be no unemployment, there will be different real wages. If however one believes that prices are rigid and it is quantities that adjust to a disequilibrium, then it is possible to have unemployment. As a compromise, some price adjustment and some quantity adjustment could mean that the impact of technology falls upon both unemployment and wages. It is worth making this point again for in none of the

1. We are not arguing that cutting real wages will necessarily lead to higher employment - only that a position with higher employment is expected to have lower real wages. Wages and employment are both considered to be endogenous to the economic system.

reports did we find any strong evidence of consideration of a wage-employment trade-off.

The above discussion of compensation effects considers only those that are "endogenous" to the economic system. There may well also be "exogenous" effects. For example, government expenditure may well be changed in response to any employment effects of new technology. We do not, however, consider that here.

Also this discussion of compensation effects has so far considered labour as an aggregate. It is of course most likely that the jobs being created through the compensation effects may require different skills, etc. than those being lost. This implies that even if compensation effects were very strong, they still provide no guarantee of full employment. In fact, one might even argue that if the compensation effects produced shortages of certain types of labour this might have further knock-on effects leading to reductions in the demand for labour in general, for example, by slowing diffusion speeds or by generating price changes encouraging capital for labour substitution.

To recapitulate our discussion above we may argue that even if new technology reduces the input of labour per unit of output this does not necessarily mean a fall in total employment, for output might respond. Any increase in output may be at least in part at the expense of non-users of the new technology, in which case it is the employees of non-using firms, industries or economies that will suffer reduced employment opportunities. Moreover any increases in output that occurs in an economy through compensation may be "distant" from the innovating source and thus structural problems may arise. We have argued that the strength of the compensation effects in any economy will depend inter-alia, upon investment behaviour, success in foreign markets, price and wage flexibility and skill structures of the labour force. The time profile of the indirect impact is also dependent on such factors. One cannot say, a priori, that the magnitude and timing of the compensation effects will always (or ever) be such as to yield equilibrium in the labour market at each moment in time. In fact one would expect some disequilibrium. The question is how large will be the disequilibrium, and this is an empirical issue. It is to this issue that much of this report is directed.

APPENDIX II

The National Commission reports referred to in this Report are as follows:

AUSTRALIA:

1. Technological Change in Australia, Vol. I, Australian Government Publishing Service, Canberra, 1980 (The Myers Report).
2. Technological Change: Impact of Information Technology, Australian Government Publishing Service, Canberra, 1981.

AUSTRIA:

Oesterreichisches Institut für Wirtschaftsforschung, Anwendungen, Verbreitung und Auswirkungen der Mikroelektronik in Oesterreich (vorläufiger Endbericht), Vienna, April 1981.

CANADA:

Microelectronics, Productivity and Employment, OECD, ICCP No. 5, 1981, pp. 137-152.

FINLAND:

Findings and Recommendations of the Finnish Technology Committee, Bank of Finland Monthly Bulletin, No. 9, 1981, Helsinki.

FRANCE:

L'informatisation de la société; by Nora and Minc, Documentation française, No. 19. (The Nora Report).

La Formation des spécialistes informaticiens, by J. Tebeka, Documentation française, 1980.

VIII Plan: "Rapport de la Commission de l'Emploi et des Relations de Travail", Documentation française, 1981.

GERMANY:

Three reports edited by the Federal Minister for Research and Technology:

1. Neue Technologien und Beschäftigung - eine Einführung in die aktuelle Diskussion (Schriftenreihe Technologie und Beschäftigung, Band 1), Düsseldorf, 1980.
2. Technischer Fortschritt - Auswirkungen auf Wirtschaft und Arbeitsmarkt (Schriftenreihe Technologie und Beschäftigung, Band 2, Düsseldorf, 1980.
3. Informationstechnologie und Beschäftigung - eine Übersicht über internationale Studien (Schriftenreihe Technologie und Beschäftigung, Band 3), Düsseldorf, 1980.

In addition, there is a report published separately:

4. Ifo - Institut für Wirtschaftsforschung, Technischer Fortschritt - Auswirkungen auf Wirtschaft und Arbeitsmarkt, Berlin 1980.

IRELAND:

Microelectronics, The Implications for Ireland, Vol. I-III, National Board for Science and Technology, Dublin, 1981.

JAPAN:

1. Microelectronics, Productivity and Employment, OECD, ICCP No. 5, 1981, pp. 155-180.
2. Research and Study Concerning Influences of Microelectronics on Employment, Foreign Press Centre, Japan, 1981.

NETHERLANDS:

The Social Impact of Microelectronics, Government Publishing Office, The Hague, 1980 (The Rathenau Report).

NEW ZEALAND:

Micro-Electronic Technology in New Zealand Industry, Department of Labour, (Draft report only).

NORWAY:

Employment and Working Conditions in the 1980s, Nou, Oslo, 1980 (English Translation).

UNITED KINGDOM:

Manpower Implications of Microprocessor Technology
(Sleigh Report) HMSO London, 1980.

UNITED STATES:

Impact of Technological Change, by R.W. Riche, OECD
Conference Paper, 1981.

REFERENCES

I. ENGLISH

- I. Barron and R. Curnow, (1979), The future with micro-electronics, Open University Press, Milton Keynes.
- E. Baum (et al), (1979), Microelectronics : secondary and tertiary changes in technology and society, FAST, CEE.
- N. Blattner (1978) "Industrial Policy - A Sceptical View, in: Zeitschrift für Wirtschafts - und Socialwissenschaften, pp. 327-46.
- N. Blattner (1981), Labour Displacement by Technological Change? - A preliminary survey of the case of micro-electronics, in: Rivista Internazionale di Scienze Economiche e Commerciali, No. 5, May.
- G.C. Chow (1967), "Technological Change and the Demand for Computers", Am. Ec. Rev., December, pp. 1117-1130. Council for Science and Society (CSS) (1981), New Technology, Society Employment and Skill, CSS, London.
- ETUI (1980), The Impact of Microelectronics on Employment in W. Europe, Brussels.
- K. Dell'mour (et al), (1980), An Input Output Approach for the Assessment of Technical Change, Austrian Academy of Science, Mimeo.
- De Melton (et al) (1980), Innovation and Technical Change in Five Canadian Industries, Economic Council of Canada, Discussion Paper No. 176, October.
- G. Eliasson, (1980), Technical Change, Employment and Growth, mimeo, IUI, Stockholm.
- ILO, Bulletin of Labour Statistics, various years, Geneva. (1971) Labour Force Projections, Geneva.

- C. Jenkins and B. Sherman (1979), The Collapse of Work, Eyre Methuen, London.
- R. Leroy (1977), General Report: Strategies for full employment in OECD, Structural determinants of employment and unemployment, 1st vol., Paris.
- A.D. Little (1979), Strategic Impact of Intelligent Electronics in U.S. and Western Europe, 1977-1987, Cambridge, Mass.
- R. Lund, (et al) (1979), Microprocessor Applications: Cases and Observations, A report for the DTI, London.
- P. McKinstry (1980), The Social Implications of Micro-electronic Technology : a survey of British Research and Commentary, Unpublished paper.
- J.P. Neary (1981), On the Short Run Effects of Technological Progress, Oxford Economic Papers, June.
- New Zealand Federation of Labour (NZFL), The Effects of New Technology in the Workplace.
- C. Norman (1980), Microelectronics at Work, Worldwatch Paper No. 39, Washington.
- J. Northcott (et al) (1980), Microprocessors in Manufactured Products, Policy Studies Institute, London.
- Norwegian Long Term Programme (1982-1985), Government Secretariat, Report No. 79 to the Storting (unofficial translation to English).
- OECD (1980), Information Activities, Electronics and Telecommunication Technologies - Impacts on Employment Growth and Trade, Vol. I, Paris.
- S. Feitchinis (1977), Studies on the Employment Effects of Technology, Calgary, November.
- Prognos and Mackintosh Consultants (1981), "The Effects of Information Technology on West Germany", in OECD, Intermedia, Vol. 9, No. 2.
- J. Rada (1980), The Impact of Micro-Electronics, ILO, Geneva.
- F.M. Rogers (1962), The Diffusion of Innovations, Free Press, New York.
- R.W. Riche (1981), see Appendix I.
- R. Rothwell and W. Zegveld (1980), Technical Change and Employment, Frances Pinter Ltd., London.

- W. Schenk (1980), The Impact of Microelectronics on Employment in Austrian Manufacturing, paper prepared to the Workshop on Methodologies to assess the Impact of Technological Change, Geneva.
- P. Stoneman (1976), Technological Diffusion and the Computer Revolution, Cambridge University Press.
- P. Stoneman (1982), The Impact of New Technology on Employment, *Revue d'Economie Industrielle*, forthcoming.
- United Nations (1980), Yearbook of National Account Statistics, 1979, Geneva.
- J.D. Whitley (et al) (1981), Employment in the late 1980's : a provisional study, Manpower Research Group, Warwick University, July.
- Z.P. Zeman and R.J. Rahn (1980), Labour Force Impact of Microelectronics, Canada, Institute for Research on Public Policy, Montreal, September.

II. FRENCH

- ANACT (1979), Informatique et conditions de travail : éléments de bibliographie, Paris.
- ANACT (1979), Les conditions de travail dans la stratégie industrielle, Lettre d'information no. 48 et ANACT : L'automatisation industrielle et ses conséquences sur le travail humain, no. 49, Paris.
- ANACT (1981), Informatique dans les emplois administratifs - Bibliographie, Paris, 126 p.
- B.I.T. (1981), Rapport de la Commission des effets des transformations techniques sur l'emploi et les conditions de travail des travailleurs non manuels, Genève.
- Bonelli, A. Fillion (1981), L'impact de la micro-électronique, Rapport pour le VIII^e Plan, Documentation française, Paris.
- Cadres CFDT (1981), Les mutations technologiques, Paris.
- G. Caire (1981), Automation : technologie, travail, relations sociales; in ADEFI : Les Mutations Technologiques, Economica, Paris.

- C.E.E. (1979), La société européenne face aux nouvelles technologies de l'information. Une réponse communautaire, Bruxelles.
- C.G.T. (1980), L'automatisation de la production - premières réflexions, CCEES, Paris.
- Y. Cohen Adria (1978), Analyse bibliographique du thème de l'automation doc. ronéoté, Ecole Polytechnique, Paris.
- B. Coriat (1979), L'atelier et le chronomètre, Bourgeois, Paris.
- Cossalter et G. Denis (1981), Les activités générées par le développement des systèmes informatiques, in ADEFI, Op. cit.
- A. D'Iribarne (1981), L'évolution du travail face au développement des technologies ; in CEREQ : L'évolution des systèmes de travail dans l'économie moderne, Paris.
- D. de Meuron (1981), Microélectronique et emploi en Suisse, Ed. Pierre Demarex, Lausanne.
- N. Dubrule, F. Ranchon (1980), Informatisation et Emploi : les secteurs Banque et Assurances, Centre d'Etude de l'Emploi, Paris.
- Entreprise et Personnel (1980), Les investissements informatiques dans l'industrie, 5 vol., Paris.
- J.P. Faure, J.L. Missika, D. Woltron (1980), Le Tertiaire Eclaté, Seuil, Paris.
- FAST (1980), Rapporto sulla Microelectronica Nazionale, Milano, 143 p.
- A. Fourcans, J.C. Tarondeau, L'impact réel de l'automation in ADEFI, Op. cit.
- M. Gaspard, Mutations technologiques et emploi à travers la crise ; in ADEFI, Op. cit.
- J.P. Jeandon, R. Zarader (1981), Informatisation et Emploi féminin, Convention Informatique, Paris.
- J. Le Quément (1981), Les Robots : Enjeux Economiques et Sociaux, Documentation française, 217 p., Paris.
- Management scientifique (1980), L'Informatisation de la Production Industrielle et ses Conséquences sur l'Emploi, Rapport à la Mission à l'Informatique, 2 tomes, 251 p., Paris.

- J.L. Messika, Les Débats sur Informatique et Emploi, in Informatisation et Emploi : Menace ou Mutation, Documentation française, 1981.
- Mission à l'Informatique (1981), Les chiffres-clés de l'Informatisation, Documentation française, 2ème édition, Paris.
- U. Muldur, R. Zarader (1981), Nouvelles techniques, nouvelles formations, Le Nouvel Automatismes, Paris.
- S. Nora, A. Minc (1979), L'Informatisation de la Société, Documentation française, Paris.
- OCDE (1979) Suisse, Etudes économiques, Paris.
- S. Paré (1979), Informatisation des Régions françaises, Documentation française, Paris.
- O. Pastré, J. Tolédano (1979), Automation et emploi : l'hétérogénéité des conséquences sociales du progrès technique, in CGP : Emploi et Système Productif, Documentation française, Paris.
- O. Pastré, D. Meyer, J.L. Truel, R. Zarader (1981) L'Impact de l'informatisation sur l'emploi en France à l'horizon 1985 in Informatisation et Emploi : Menace ou Mutation, Documentation française, Paris.
- O. Pastré (1981), Informatisation et Emploi : de faux débats autour d'un vrai problème, Revue d'Economie industrielle, Paris.
- H. Pigeat, L. Virol (1981), Du Téléphone à la Télématique, Rapport pour le VIII^e Plan, Documentation française, Paris.
- C.A. Sarre (1980), L'Informatisation des Entreprises françaises dans les années 80, Institut de l'Entreprise, Paris, 92 p.
- A. Sole (1980), Concevoir des alternatives technico-organisationnelles Informatique et Gestion, n° 118, Paris.
- C. Stoffaes (1981), L'Emploi et la Révolution informationnelle in Informatisation et Emploi : Menace ou Mutation, Op. cit.
- J. Tebeka (1980), La Formation des Spécialistes Informaticiens, Rapport au Premier Ministre, 74 p. Paris.
- E. Verdier : Informatisation et Emploi dans le secteur des assurances, in ADEFI, Op. cit.

VIII° Plan (1981), Rapport de la Commission de l'Emploi et des Relations du Travail, Documentation Française, Paris.

VIII° Plan (1981), Rapport du Groupe de travail sur l'Emploi dans les Services, Documentation Française.

III. GERMAN

N. Blattner and B. Mordasini (1981), Die Arbeitsproduktivität in der Schweiz 1960 - 1980: Entwicklung und Versuch der Erklärung, in: Die Volkswirtschaft, 55Jg.

W. Dostal (1981), Technischer Wandel und Beschäftigung, in: Zukunftsprobleme der Sozialen Marktwirtschaft, Berlin.

W. Dostal, M. Lahner and E. Ulrich (1977), Datensammlung zum Projekt Auswirkungen technischer Aenderungen auf Arbeitskräfte, Beitrag 17, Nürnberg.

Finanzierungsbeihilfe zugunsten bedrohter Regionen
(1978) Bundesbeschluss vom 6. Oktober 1977, Berne.

M. Lahner and R. Grabiszewski (1978), Datensammlung zum Projekt Auswirkungen technischer Aenderungen auf Arbeitskräfte, Beitrag 22, Nürnberg.

Sachverständigenrat für die Begutachtung der wirtschaftlichen Entwicklung (1981), Jahresgutachten 1980/81, Bonn.

L. Scholz (1980), Kommt es zu einer 'technologischen' Arbeitslosigkeit? in: Wirtschaftsdienst, VIII, Hamburg.

Statistisches Handbuch für die Republik Oesterreich
(1979) Vienna.

P. Stolz (1982), Technischer Wandel, Rationalisierung und Arbeitsmarkt, in: Die Unternehmung, 36 Jg.

Wifo (1981), Statistische Uebersichten, 54 (6), Oesterreichisches Institut für Wirtschaftsforschung, Vienna.

B. SELECTED DISCUSSANTS' REPLIES

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COMMENTS

by

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Berlin, Germany

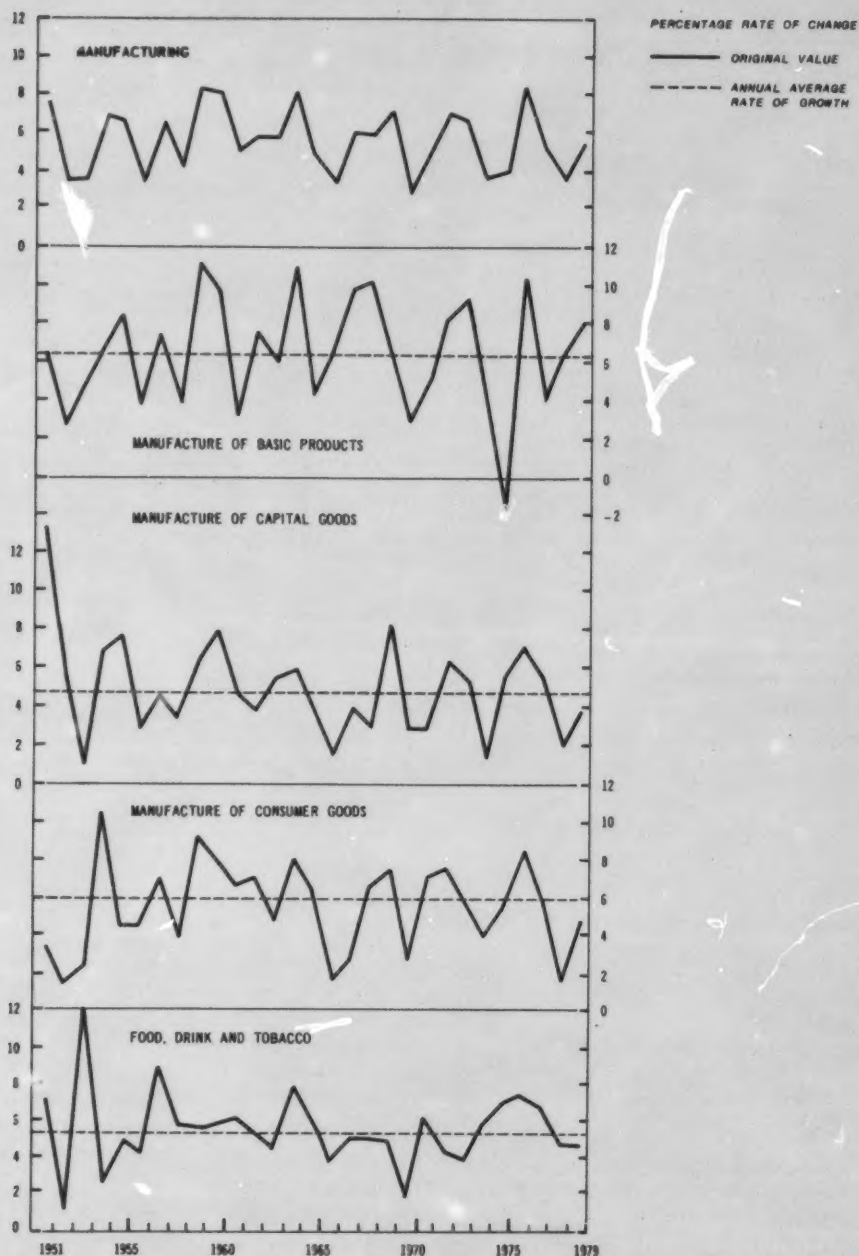
It is not an easy task to comment on a paper which is, on the one hand, only reporting other studies and which is, on the other hand, well done especially in being cautious with respect to easy conclusions. Altogether I would share the general view expressed in the paper that the impact of micro-electronics on employment is more of an evolutionary than of a revolutionary type. One could even generalise the argument by pointing out that the productivity growth in manufacturing has followed a very stable course since the fifties irrespective of the introduction of electronics.

It is surprising that the picture for the seventies is indeed not very different from the picture for the sixties. A recent study of the German Institute of Economic Research (DIW) shows this very clearly for the Federal Republic of Germany(1). This study indicates that the productivity per hour worked follows an exponential trend in a very stable manner. From the fifties up to the end of the seventies the manhour productivity

1. Compare: Längerfristiges Wachstum der gewerblichen Arbeitsproduktivität seit 1950 wenig verändert. Bearbeiter: Arthur Boness, Rolf Krengel, Rainer Pischner. In: Wochenbericht des DIW. Nr. 48/80, S.505.

See also: Deutsches Institut für Wirtschaftsforschung, Abschwächung der Wachstumsimpulse. Analyse der strukturellen Entwicklung der deutschen Wirtschaft. Strukturberichterstattung 1980. Beiträge zur Struktur-forschung, Heft 61/1981. Duncker & Humblot, Berlin 1981, especially page 82-85.

DEVELOPMENT OF MANHOURLY PRODUCTIVITY IN MANUFACTURING IN GERMANY



Source : German Institute of Economic Research. «Längerfristiges Wachstum der gewerblichen Arbeitsproduktivität seit 1950 wenig verändert».
 Bearb. : Arthur Boneß, Rolf Krenzel, Rainer Pischner. In : Wochenbericht des DIW, Nr. 48/80, S. 505.

Table 1
Effects of Structural Changes in
Final Demand on Employment

	1963-65	1966-67	1968-73	1974-76	1977-78
	- 1,000 persons -				
Components of final demand					
Private consumption	- 330	- 230	- 730	- 810	+ 80
Government consumption	+ 220	+ 80	+ 420	+ 280	+ 70
Gross investment	+ 150	-1,260	+ 260	-1,170	- 70
Machinery and equipment	- 100	- 260	+ 150	- 450	+ 90
Construction	+ 130	- 460	- 120	- 810	- 80
<u>Final domestic demand</u>	+ 40	-1,410	- 50	-1,700	+ 80
Exports	+ 200	+ 460	+ 880	+ 80	+ 70
Total employment	+ 240	- 950	+ 830	-1,620	+ 150
Potential labour force	+ 230	- 380	+ 540	- 430	+ 70
Unemployment(1)	- 10	+ 570	- 290	+1,190	- 80

(1) Including hidden reserve.

Source: Input-output-analysis of the DIW.

Source: Deutsches Institut für Wirtschaftsforschung, Abschwächung der Wachstumsimpulse. Analyse der strukturellen Entwicklung der deutschen Wirtschaft. Strukturberichterstattung 1980. Beiträge zur Strukturforchung, Heft 61, Berlin 1981, S.47.

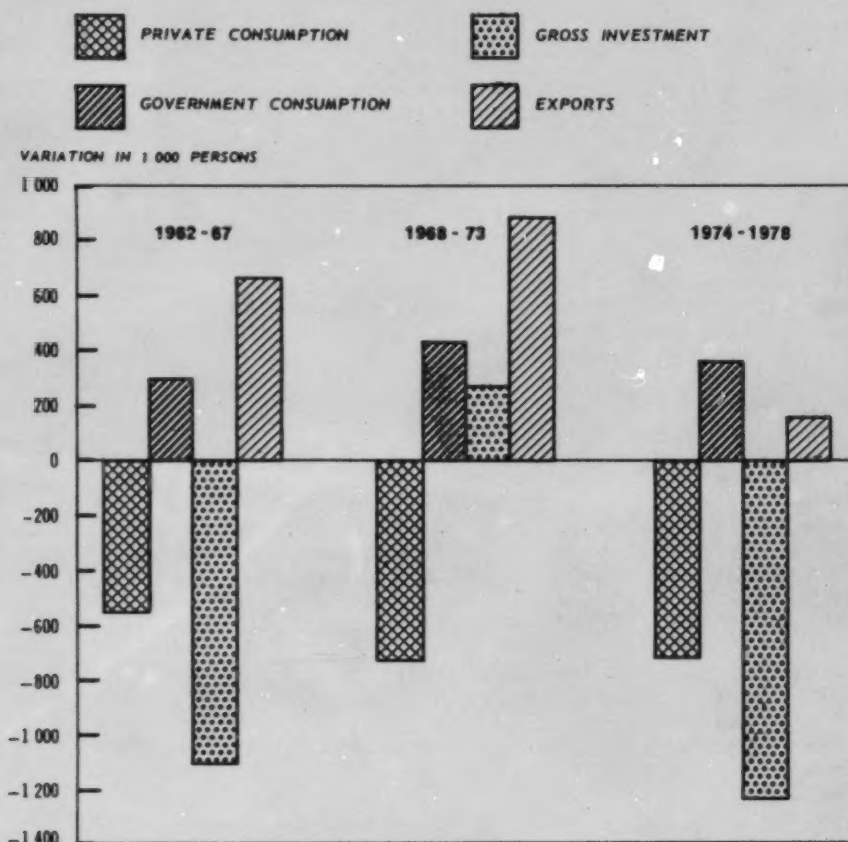
is growing with an average yearly rate of 5.5 per cent for the manufacturing industries. Regression analysis shows no evidence that there is a significant deviation or a structural shift in this development. The experience of the past does not show any considerable influence of microelectronics even if it is not quite clear whether this can be related to a low diffusion speed or a small change in productivity by microelectronics. There is, however, some evidence that the main cause is a low speed diffusion.

The relatively stable growth in productivity, however, raises the question how the employment can be solved if the rate of economic growth is below the rate of productivity growth. This situation becomes even more difficult if a growth in labour supply can be expected as is shown in the report.

There are some compensating effects which are dealt with in the paper in a very competent way. Taking the German experience, however, I would like to point out that, at least in the past, another type of compensation has been dominant in the development of the Federal Republic of Germany. In a report of the DIW on the structural development of the German economy(2) we have used input-output techniques to calculate the part of the labour force which is necessary to produce the different components of final demand. Table 1 covers the sixties and the seventies. It shows that the number of people working for private consumption has become smaller in a very stable manner. A similar development (although less significant) is valid for investment. The first compensating effect was increased government employment. As far as I know about the developments in other countries there are similar developments in many countries. After the compensation by enlarging government employment came to an end, in the midst of the seventies, in the case of West Germany an increase in exports was the second compensating effect of the type dealt with in the report. The experience of Germany in the early seventies shows the importance of this compensation and of its exhaustion, as it was followed by a considerable increase in unemployment on a level which had been observed earlier in other countries.

2. Compare: Deutsches Institut für Wirtschaftsforschung, Abschwächung der Wachstumsimpulse. Analyse der strukturellen Entwicklung der deutschen Wirtschaft. Strukturberichterstattung 1980. Beiträge zur Struktur-forschung, Heft 60/1981. Duncker & Humblot, Berlin 1981, page 46 ff.

EFFECTS OF STRUCTURAL CHANGES IN FINAL DEMAND ON EMPLOYMENT Changes in labour force working for components of final demand



Source : Input-output-analysis of the DIW., based on table 1.

This could be interpreted as a development with relatively stable structural relations where independent of the question of microelectronics the productivity growth is larger than the growth of output. This means, even without an increased labour supply, that the structural compensating forces are not large enough to avoid an increase in unemployment. In this context Dieter Mertens from the Institute on Labour Market and Occupational Research, referring to the forecast experience of the last decade, describes the 'Beharrlichkeit'

struktureller Trends' (reliability of structural trends) with respect to short-term shocks or developments(3).

A similar increase in unemployment can be observed in many of the industrialised countries. Therefore, even if there is no doubt that there may be compensating forces especially in the context of a neo-classical argument, the question remains for which reasons these forces are not large enough to avoid a further increase in unemployment. The point that a denial of the use of microelectronics makes especially in an open economy the situation even worse is only a weak comfort for a country which uses microeconomics and still faces a remarkable unemployment problem.

It is not likely that a single cause is responsible for this situation. In the report some causes are mentioned. Especially a disequilibrium on the labour market with respect to required skills on the one hand, and education and training on the other hand, may have a considerable influence. This disequilibrium is not independent from the introduction of information technology and it may therefore be a good argument that part of the problem can be dealt with by an adaptation of the labour supply. Limits for this process exist in any case for old people. It is questionable whether limits of this type exist for younger people as stated in some of the national reports. In this case the point could be made that part of the employment problem could be solved by better education and training.

But even if one agrees that this is a very important point and that the further development will depend to a considerable part on the question how an economy solves this problem, there remain some questions to be answered. In a neoclassical world, supply and demand for goods and factors are in equilibrium. There may be short-term disequilibria but at least for the mid-term there seems to be no reason why demand and supply should not be in equilibrium. The situation described above can be explained on Keynesian lines by the fact that the employment problem is partly due to missing demand. Why does demand not grow in the same way as the potential output increases? Private consumption cannot be the reason. Even if the growth of government expenditures

3. Compare: Dieter Mertens, Von der Beharrlichkeit struktureller Trends. Reflexionen zur Prognostik des vergangenen Jahrzehnts. In: Mitteilungen aus der Arbeitsmarktund Berufsforschung, Schwerpunkttheft: "Das prognostizierte Jahrzehnt", Die siebziger Jahre-Vorausschau und Wirklichkeit, 13. Jg., Heft 3, Verlag W. Kohlhammer, Stuttgart, Berlin, Köln, Mainz 1980.

has come to an end it cannot explain the gap in demand. This statement, however, does not hold for countries which cut back their real government expenditures to a considerable extent. It is however too early to discuss the results of this type of policy.

In this context the crucial point of a Keynesian argument is the development of investment. Could it be possible that the introduction of microelectronics reduces not only the labour input per unit of output, but also the necessary capital input per unit of output in a considerable way? Could this at least partly explain the sharp decrease in investment expenditures observed in the second half of the seventies?

There are some case study arguments which support this view. The sharp decrease in prices of information technology equipment, the flexibility of microprocessors for quite different and changing applications may lead to a situation where marginal capital investments are sufficient to reach considerable productivity increase. Information technology would lead to a decreasing capital coefficient and so change the way technical progress is introduced into the economy.

If this is true, or to put it in another way, if this contributes at least partially to a development where less investment than before is necessary to reach a given output, then the gap in demand could be explained partially by this gap in investment.

Up to now it is not clear whether developments of this type play a decisive role. Taking the weaknesses of other explanations for the structural cause of unemployment, however, it could be useful to broaden the analysis. Even if one is interested only in the solution of the employment problem it may be useful not only to ask for the impact of microelectronics on employment but also for the impact of microelectronics on investment or on the development of the production apparatus. Therefore, I think the further discussion should be broadened to include the capital side of development also.

It is very difficult to draw policy conclusions from these comments. Taking into account that the impact of new technologies, especially microelectronics, is of considerable importance for the development of productivity the speed of diffusion of these technologies could be influenced by policy. On the one hand we can count upon a high increase in productivity even with a relatively low diffusion speed. Even in this situation we have some serious difficulties with low growth rates and low macroeconomic demand. Political steps to increase the diffusion speed would add to these difficulties.

On the other hand the question whether this productivity growth is sufficient will be decided by the world market. Taking the German situation, the economy does still have a good position in the world economy, although rapid development elsewhere in some modern technologies may endanger this situation. Therefore, to secure the future, it would be necessary to reach a higher diffusion speed. This would mean, however, to care much more than has been done in the near past for macroeconomic demand. For the reasons mentioned above higher diffusion speed may decrease the demand for consumption and investment as well. If the demand, however, is not sufficient it is very difficult to give incentives for investments in new technologies.

These considerations allow, however, at least one important conclusion: Taking into account the evidence provided in the report and in this commentary, policy directed only to the introduction of new technologies by improving the supply conditions - as it is advocated by the so-called supplysideeconomics - is not sufficient. The political discussion between Keynesian and supply-side-economics is misleading. These policies are not alternative but complementary. A successful supply-oriented policy inducing new investment with new technologies will increase the problems on the demand-side. Therefore, it has to be supplemented by a policy on the demand-side.

COMMENTS

by

A. HEERTJE

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There are many points in the report I am in full agreement with. For example, the stress on the supply side of the labour market and on the micro effects of technology. It does not make much sense to think in global terms. Global statements instead of being global speculations should be based on detailed micro-economic studies. Global statements about the influence of this type of technology on employment or about the labour saving or capital saving character are not well founded in general. In Holland I have myself directed some descriptive microeconomic studies on the introduction of new technology within the framework of specific companies and I think that the results are also applicable to microelectronics technology. We can learn a lot from these descriptive microeconomic studies and we get specific information about direct and indirect labour effects - not only the direct effects on employment and so on, but also the indirect influences. Indirect in time, because we see that some effects only work themselves out after some time and thus you do not realise that the effects you see over time are in fact related to the introduction of the new types of technology at a previous stage. There are also indirect and unforeseen effects in other sectors of the organisational structure of the firm and also often very unforeseen. We obtain an insight into the influence of the new type of technology on productivity and we realise that the main problem is not unemployment in general but, as has been said already, the adaptation of people to new possibilities, to new technologies, in short the problem of reschooling. In this respect we might perhaps realise that we are all used to change but that nobody in fact, accepts change. It is still a very difficult problem and we should not underestimate the big psychological problems that are involved here. We also realise again that a natural effect of this type of technology is the possibility of a reduction of labour time, but this

again is a very general statement. From careful studies it follows that there is by no means a homogeneous pattern. There are sectors within the firm and also among firms where you could reduce labour-time but there are also other sectors where you have to increase labour time because there is a lot of work to do. One of the major problems in the future will be the heterogeneity of the pattern. This may cause tensions in the discussion between labour unions and employee organisations. But there is even more to learn. It is not just a matter of welfare effects that express themselves through the market as productivity and employment. There are other important welfare effects which you can embrace through the broad concept of welfare that are highly involved, highly attached and highly related to, in particular, this new kind of technology - microelectronics and communication technology. I refer to the significance of the new type of technology for job satisfaction, the quality of labour, the working conditions, the environmental issues involved, the possibility of the saving of energy, the influence of the new technology and the quality of the production process, on the quality of the product as such. All these welfare effects which at least partly work themselves out outside the market sphere and which you cannot express in terms of financial calculations, are still very important, because they still have an impact on the allocation of resources. The essential point here is that we as economists should realise this and should realise that essential economic aspects are involved although they are based on preferences which are not expressed through the framework of the market. Although they express themselves outside the market, they are still very important. This may lead to new forms of decision-making within the firm in so far as one has to rely on the preferences of the people which are not suited to be translated in terms of money and prices. So one has to rely on the opinion and views of people themselves, but there is still an economic problem involved in so far as choice has to be made as to the weighing-up of the quality of labour, the environmental issues, the employment effects, etc., etc.

So, we have to take a broader look than just the employment effects, but there is even more. The relation between this type of technology and technology in general, technological change and society and social developments is not a one way avenue. It is not just a matter of introducing the new technology and seeing what are the social effects, but it is also, I think, true that there are important social developments which have a certain influence on this type of technology and on the future modification of this type of technology. Let me just briefly give a few examples: the need and the wish to work at least partly at home, partly due to

traffic congestion for example, is made possible and will be made possible through the introduction of the new types of communication technology and I am inclined to think that in the future the further adaptation and modification of this type of technology will at least partly react to social developments. The preferences of the people for flexi-time, job sharing and part time work will be made possible by the new information and communication technology and this is, I think, a new development in our age, in our period, because there is a matching so to speak of social developments and the new technologies. So, there is an interchange between social and technical change and this insight makes it even more appealing, I think, to base our global views on detailed microeconomic studies and to realise that productivity and employment effects are important, but that they are not the only effects that play a role in the broader economic cost benefit analysis of the implementation and diffusion of the microelectronic technology. On balance I would like to point out that the new technology opens major new opportunities to raise the welfare of the people in the broad sense and there is so much work to do that you realise that in so far as we discuss unemployment in a general sense, we must also realise that it is not technical change that is responsible for this major social problem. In discussing the issue of unemployment we should not place the wrong crook on the stage.

COMMENTS

by

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Introduction

Faced with the task of synthesising the diverse collection of National Reports on the productivity and employment implications of microelectronics technology, the consultants: Paul Stoneman, Niklaus Blattner and Olivier Pastré have provided this Session with a careful and judiciously balanced review of such fragmentary and often inconsistent pieces of empirical evidence as are on hand. They have furnished a coherent framework within which the labour market impact of technological innovations may be analytically examined - a framework that treats the "generic" aspects of technological change rather than directing attention to the distinctive characteristics of the revolution in information technologies being wrought by developments in micro electronics. It addresses questions that might equally be asked concerning the eventual productivity and employment implications of recent advances in recombinant genetics, or in fibre optics. Proceeding within this general framework, the Consultants' Report devotes its main emphasis to assessing the magnitude of the primary, labour-displacing effects of the productivity improvements associated with the diffusion of microelectronics innovations, on the one hand, and to identifying and evaluating the strength of possible compensatory, employment-generating effects on the other hand.

Economists and Technological Unemployment - from Ricardo to the Report

As a fellow economist, I naturally find it reassuring that the Consultants' Report adopts the time-honored stance of our profession, which is to remain optimistic regarding the effects of technological change but to eschew becoming cavalier about the risks of

technologically induced unemployment and other possible consequences prejudicial to general economic welfare. Economists' efforts to preserve this ambivalence can be traced back easily as far as the writings of Ricardo on the subject of technological unemployment.

Indeed, it is quite striking to observe how faithfully in both substance and tone the text of the Report before us recapitulates themes originally enunciated more than 160 years ago, in the midst of the First Industrial Revolution. David Ricardo, it should be recalled, also was a long-run optimist regarding the possibilities for economic progress: he saw continued technological change (and the opening up of international trade along the lines of comparative advantage, of course) as avenues leading away from the dismal slough of the stationary state. Yet there was in Ricardo's writing a strong tension between long-run hopes for continuing technological improvements and worries about the more immediate consequences of such changes. It is this tension which has periodically mounted and abated, without ever being resolved in the economic literature.

As Mark Blaug has pointed out, the general pre-occupation of Ricardo's analysis of economic processes was with long-run equilibrium outcomes, whereas his treatment of the impact of technological "improvements" upon wages, profits, and rents, concentrated largely upon the short-run(1). Nowhere was this so striking as in the famous Chapter 31, "On Machinery," which Ricardo appended to the third edition of his Principles in 1821. This brief chapter managed to shock his readers and provoke a "furor of debate" among contemporary political economists(2), by suggesting that the introduction of laboursaving machinery might be injurious to the workers, causing unemployment when real wages could not be forced downward. Ricardo introduced this heresy after restating his own prior orthodoxy - that

"an application of machinery to any branch of production, as should have the effect of saving labour, was a general good, accompanied only with that portion of inconvenience which in most cases

1. Mark Blaug, *Economic Theory in Retrospect*, Third Edition, Cambridge: Cambridge University Press, 1978, pp. 111-12.

2. Cf. Maxine Berg, *The Machinery Question and the Making of Political Economy, 1815-1848*, Cambridge: Cambridge University Press, 1980, p. 44.

attends the removal of capital and labour from one employment to another(3).

Putting aside the frictional "inconveniences" as commonplace, the longerrun sanguine view was grounded upon the now classic "compensation effects" argument: improvements, in the form of mechanisation of production, would lead to a reduction in commodity prices from which all customers would benefit, including the labouring classes. Even if productive capacity in one branch of industry grew faster than demand there, displaced workers would be reabsorbed in employment elsewhere(4).

The particular difficulty whose recognition Ricardo felt himself obliged to announce in 1821 was one that could arise in the transition to a more machine-intensive technique of production. If output had to be diverted from consumption purposes to the production of capital goods, the supply of commodities for consumption as wage goods would fall - to the detriment of the labouring population. At least temporarily. Once the new machines came "on line", so to speak, the supply of wage goods gradually would be augmented, prices would fall, and labour could be reabsorbed into employment without there being a significant reduction in real wages. (*Works*, I, pp. 389-90.) Economists in the developed countries no longer worry about precisely this form of transitional unemployment arising from technological progress(5). But it is worthwhile noticing that the potential problem of "structural" unemployment, acknowledged in the present Report, is fundamentally a similar condition - one in which prolonged displacement of workers results from supply-side constraints rather than from an insufficiency of aggregate effective demand.

3. *The Works and Correspondence of David Ricardo*, vol. I: on *The Principles of Political Economy and Taxation* (edited by P. Sraffa), Cambridge: Cambridge University Press, 1951, p. 387. All page references in the text hereafter are to the Sraffa edition.

4. Cf., *Works*, I, p. 387. Ricardo seems to have had in mind an expansion of labour demand in branches producing commodities (other than food) for which the price elasticity of demand was quite high. But the key explanatory passage was ambiguous enough to have referred equally to shifts in demand due to the income effects of the price reductions in the branch where mechanisation was occurring.

5. But cf., J.R. Hicks, *A Theory of Economic History*, Oxford: Oxford University Press, 1969, pp. 151-54, 168-71, J.R. Hicks, "A Neo-Austrian Growth Theory," *Economic Journal*, Vol. 80, No. 318 (June 1970), pp. 257-281; E.F. Beach, "Hicks on Ricardo on Machinery," *Economic Journal*, Vol. 81, No. 324 (December 1971), pp. 916-22.

Looking at the likely developments of the supply and demand for labour during the coming decade, the Consultants have concluded that the spread of micro electronics will not exert a markedly adverse effect upon the balance between the aggregates. What worries them more is the prospect that the structure of skill demands, and the industrial structure itself, will most probably be altered so as to curtail job opportunities for young unskilled workers generally, for the older and least mobile members of the workforce attached to traditional branches of commodity production and trade, and for females seeking secretarial and clerical positions without higher educational or skill qualifications. Redundancies may therefore persist among such groups, even though the want-ads continue to advertise vacancies for designers and engineers in microelectronics, computer programmers, and electronic office equipment sales and service representatives. One way to think about this is to see the problems as rooted in a lack of savings required to carry out the socially requisite human capital formation accompaniments to investment in hardware embodying the new technology. Such complementary human capital formation would initially furnish new workers, and re-equip old ones, with the skills sufficient to allow their absorption, or re-absorption, into productive employments at the formerly prevailing real wage level.

In a pure market economy the lack of savings for such purposes could arise because the private rate of return on the necessary investments in people was too low, or because imperfections in capital market institutions denied some people access to financing. Yet even where the political and institutional context would facilitate public educational and retraining investments, it is possible that the investment cost of re-training displaced older workers is so high, and the pay-off period so brief, that any positive social rate of discount would imply that retiring such workers at their former wage levels would be socially less wasteful than re-equipping them for private sector employments at those wages.

The public policy issue posed by this line of analysis then turns on the question of whether or not the present value of the stream of producer and consumer surpluses yielded by the new technology would be large enough to cover not only the direct investment costs, but also the present value of the incremental social outlays for worker retraining and/or premature "retirements." A positive answer, of course, is no guarantee that the society will opt actually to spend the productivity gains from microelectronics or other technological advances on "subsidies" for education, retraining and retirement.

Ricardo's long-run optimism only carried him so far as to contend that the labour-saving improvement eventually would generate enough additional income and savings to cause the reemployment of a workforce of the original size. The workers, therefore, would be hurt in the interim, and he had to grant

"that the opinion entertained by the labouring class, that the employment of machinery is frequently detrimental to their interests, is not founded on prejudice and error, but is conformable to the correct principles of political economy." (Works, I, p. 392).

What I get from the Report at hand is not so much the feeling that alarms on this score are empirically unjustified in the case of microelectronics, but rather the suggestion that the danger of reactive public policies grounded in such alarms is very worrisome for open economies in today's climate of international competition. In this final respect too, the Consultants have arrived at precisely the same point as Ricardo, who concluded that "the employment of machinery could never be safely discouraged in a State" (Works, I, p. 396), since to inhibit the use of more productive techniques, when one's foreign competitors did not, was likely to have an even more disastrous impact upon domestic employment.

To recognise that it would be economically more costly for a modern industrial society to seek to "protect jobs" by limiting the application of microelectronics, and that such policies are likely to be self-defeating, does not, to my mind, provide any warrant for minimising the potential severity of the adjustment problems and conflicts that may surround the introduction of these new technologies. The greatest danger of overstating the magnitude of the factor market dislocations arises when it is perceived that social mechanisms for compensating damaged parties are non-existent or inadequate. The danger is that those who, rightly or wrongly, anticipate that they may sustain significant injury will, in such circumstances, act unilaterally or in concert to preserve their immediate interests by blocking the impending changes. Most of modern economic analysis, which dwells fondly upon the operation of endogenous, market-channelled mechanisms of "compensation", seems to give insufficient attention to the transitional difficulties that will befall some individuals, and to dwell instead upon the long-term benefits that accrue to society as a whole from the introduction of technological improvements. In a perverse way, it may thereby actually promote the worrisome perception that little will be done to prepare politically directed - social machinery for the provision of compensatory assistance to the victims of change. This contributes to creating a climate in which the economist

may well feel it is "more responsible" to risk erring on the side of over-sanguinity than to risk erring on the side of alarmism.

Compensation Effects and the Long-Run Employment Outlook

Without intending to impute any such conscious motives to our team of Consultants, I wish to suggest that their Report has perhaps gone farther than might be useful in the direction of eschewing alarmism. As far as the long-run labour market prospects are concerned, the sanguinity of the Report appears to derive mainly from the appraisal of the so-called "compensating effects" as being collectively quite large in relation to the anticipated rate of job-displacement due to the diffusion of microelectronic innovations. There surely is ample room here for doubt, and at least two notes of scepticism and worry should be sounded. The first concerns what we presently do and do not know about the magnitudes of labour-savings and compensating effects at various levels between the individual establishment and the macro-economy. The second concerns the possibilities of serious disjunctions in the spatial or the temporal occurrence of job displacement and job-creation.

There is much need for detailed engineering information about the factor-saving and factor-using biases of microelectronic technologies in a variety of production contexts, but also about the ease with which various inputs may be substituted for one another - given the production technology that is in place. It is not sufficient to trust that because an innovation "will only be introduced (rationally) if the services it provides are cheaper than with the previous technology", the tendency to use such services more intensively will substantially counteract the shrinkage in the demand for the productive inputs. Microengineering data at the process and department levels, as well as organisational design information for the establishment, is needed to tell us how much substitution response can occur when the relative efficiency-prices of some inputs are reduced. At best we may take the presumed existence of some intra-plant compensation effects as qualifying the impression conveyed by partial engineering analyses; but the direction of the qualification is not always unambiguous or reassuring. Engineering data which show the number of welders displaced from automobile production lines by automated spot and arc-welding machines like robots, do not also indicate that (cheaper) welding may also have been substituted for other assembly techniques - with further labour-displacing consequences.

When the analysis moves to the level of the firm, the effects of a labour-saving technological innovation upon unit costs, and the effect of the cost change upon

prices and the volume of sales, must be considered in order to gauge how large an offsetting increase in labour demands will materialise. Under conditions of perfect competition one is justified in supposing that all unit cost savings are translated into price reductions. When firms hold market power, however, the form of the cost savings becomes a crucial issue determining the existence or non-existence of a tendency towards the compensating expansion of production. The reduction of marginal costs would occasion some expansion in the volume of production of a firm which had monopoly power, just as it would in the case of the perfectly competitive firm. But a reduction in fixed costs would not have the same effect, as it would leave the profit-maximising volume of output unaltered and simply raise the monopolist's profit level. Inasmuch as we do not live in a world in which perfect competition is the norm, it becomes important to know more than we now do about the way the introduction of microelectronics will impinge upon the fixed and variable elements of cost in the various branches of production. Casual empiricism is less than reassuring on this point: it suggests that since computerisation of record-keeping and control functions (i.e., inventory management), as well as in a range of clerical support services, is likely to have maximum impact in displacing non-production workers who represent elements of quasi-fixed costs for manufacturing establishments, the existence of compensating effects through the expansion of production in those plants will depend critically upon the strength of the competition to which manufacturing firms are exposed.

This brings me to the second point. The existence of international competition provides some grounds for reassurance that cost savings in all forms may lead to compensating increases in output and labour demands, or will at least stave off losses in market share and domestic employment opportunities. But to seize upon this argument is to grasp a two-edged sword: the logic of the analysis of compensation effects offers nothing to guarantee that all the employment generating repercussions of the introduction of a labour-saving innovation will compensate the region or nation in which the job displacements have occurred. Design engineers and machinists may be put to work in Cincinnati, Ohio, building dedicated industrial robot systems that will displace workers (at some subsequent date) from the paint-spraying departments of automobile plants in the environs of Detroit, Michigan. But we soon would begin to think differently about this, were Ohio and Michigan two different countries - or even in two very distinct regions of the United States. Actually, in contrast to the American pattern of specialisation in robot production, major automobile makers in West Germany, France and Japan have been extensively engaged in building robots for their own use. Yet, watching Toyota and

Volkswagen increase their hold upon both the automobile and the numerically controlled machine tool markets cannot be much compensation for workers in Britain's industrial midlands. And what of the effects upon the Turkish labour market, not to mention the balance of payments, if Volkswagen-built robots displace many immigrant workers from semi-skilled automobile assembly jobs in West Germany? It may seem awkward, and unnecessarily divisive on this occasion to name names and places. But these or similar realities eventually will have to be faced. Unless we bear them in mind, we cannot begin to think constructively about the international dimensions of the coming microelectronic revolution.

The international repercussions may indeed prove to be more far-reaching than has hitherto been suspected, making it all the more important to discard the implicit closed-economy premise upon which has been based much of the traditional economic literature concerning compensation effects. International competition in information-intensive activities may alter substantially the situation that has long prevailed in those sectors of many economies which enjoyed a large measure of protection by virtue of the "nontradeable" nature of the services they produced. Non-tradeability may turn out to be too evanescent a quality to be relied upon. As developments in satellite communications, microwave transmission, and, eventually in applications of fibre optics, further reduce the already low marginal costs of transporting information as a commodity, there will be further efforts to remove legal, institutional and other barriers - including those of national language differences - to trans-national trade in information intensive services. This may have profound effects, bring about a restructuring of those parts of the service industries which operate in financial markets, in shipping and insurance brokerage, and in commodity markets where economies of scale and specialisation in the acquisition and processing of information are very important. Thus, the service sectors of many national economies, which have in the past decades absorbed an increasing share of domestic employment, increasingly centered in information-based occupations, may now in my view have reached a state in which profound dislocations can occur as a result of their exposure to international competition. To be sure, there will be gains from trade. But in any single economy the longrun employment prospects may not be so assured.

Life in the Short-run: Transitional Problems and the Macro-economic Outlook

As for the short-run - in which, and Keynes reminded us, life such as it is must be lived - the Report

candidly admits that labour markets should not be expected to function smoothly in matching currently available labour supplies to the altered pattern of labour demands implied by the introduction of micro electronic technologies. Hence, even if the long-run employment picture were unclouded by prospects of a net displacement of workers, transitional dislocations could turn out to be serious enough to call for new public measures in addition to a strengthening of existing "safety-net" provisions. The magnitude of such difficulties, and of the consequent burden they will place on the existing unemployment, social insurance and welfare apparatus, will be greater or smaller depending upon two sets of factors. The first are those affecting the rate of initial job-displacement, which is to say, the rate of reduction of unit labour input requirements at the plant or establishment level brought about by technological innovations, and the pace at which such innovations are introduced. The second set of factors are those which will influence the functioning of labour markets, either by altering the price and quantity signals, and the costs of such information to the workers and firms, or by affecting the speed with which the participants can respond to signals of excess supply or excess demand.

Under the heading of the first of these considerations, it may be worth starting with the observation that the extent of plant level job displacement connected with productivity-enhancing technological change is almost certainly greater than one would be led to surmise from empirical studies carried out at the industry level, or still higher levels of aggregation. Over any era in which demand for an industry's products has been expanding, jobs lost through the modernisation of existing production facilities are likely to be offset in some part, if not entirely compensated for, by jobs created through the opening of new plants in different locations. The magnitude of the required labour market reallocations is therefore generally under-represented by statistical studies which find weak or non-existent job-displacement effects of technological change at the industry, sector, or domestic-economy levels.

This is not mere theoretical conjecture. A special study, motivated by the concern that technological displacement of labour at the plant or establishment level might be more extensive than that appearing at the industry level, was undertaken in the 1960's by the U.S. Bureau of Labour Statistics for the National Commission on Technology, Automation and Economic Progress(6). The

6. National Commission on Technology, Automation and Economic Progress, The Employment Impact of Technological Change, (Appendix Vol. 11 of Printing Office, February 1966, pp. 11-9 through 11-25.

evidence gathered from establishments in 17 4-digit SIC industries over the period 1947-1961 reveals that labour productivity advance displaces production worker man-hours at the same level, i.e., the establishment, at which it occurs; that if there are immediate compensation effects these are at best only partial, and less likely to occur within the same establishment when aggregate demand is weak. In fact, it was found that during an episode of adverse macroeconomic conditions, the negative association between employment growth and productivity advances at the establishment level was more clearly evident, and that the plant "disemployment" rate was higher within those industries in which the negative employment-productivity covariation was most marked. In sum, the long-run growth of employment and productivity which is observed at the level of industries and entire economies may warrant faith that technological advance conveys benefits to the working population as a whole, and may even support the Consultants' contention that the application of microelectronics is unlikely to produce an aggregate deficiency of employment opportunities in the 1980's; but it should not be taken as indicating that the technologically-induced displacement of workers is only a minor problem for modern industrial economies.

Perhaps a sounder basis for discounting the possibility of temporally bunched, massive dislocations in labour markets is to be found among the factors affecting the rate of diffusion of the new, micro electronic technology. The Report quite properly observes that the historical experience of the diffusion of process and product innovations suggests that progress towards widespread adoption will occur far more slowly and gradually than some journalistic previews of "the Microelectronics Revolution" would lead one to expect. Moreover, it details many specific conditions - ranging from inadequacies of the telecommunications infrastructure, to the resistant attitudes of management personnel - which have been identified as impediments to the introduction of micro-processors by firms during the 1970's.

In this connection, a point deserving of more notice than it has received is simply that the rate of technological diffusion is not determined outside the economic environment in which adopting firms must operate. Rather, the diffusion process itself, no less than the eventual extent to which new products and processes supplant old ones, is subject to endogenous controls exerted by conditions in the markets for goods and factors of production. Thus, the conditions of structural disequilibrium which the Consultants fear may emerge in labour markets - redundancies among skilled and semiskilled workers, coupled with shortages of computer programmers, electronic engineers, and the

like - would operate reflexively to slow down the diffusion process that was generating those excess supplies and demands. The existence of this feedback loop provides an important stabilising effect for the system as a whole. If rapid adoptions of a labour-displacing innovation by many firms were to leave in their wake severe unemployment and social dislocation, it is unlikely that this damaging course of development would proceed unchecked except in very small, open economies; elsewhere, the labour market effects on relative wage rates and therefore on the inducement to save labour, and possibly also the adverse income effects of the loss of employment upon the demand for investment in new capacity, would militate against continued diffusion of the innovation. Induced political action to regulate the introduction of labour-displacing technologies would constitute a nonmarket feedback loop, but one that many suspect would prove less easily reversible in its operation.

All stabilising processes, whether they work through market or through non-market channels, must impose some costs upon the economy. In this instance technological changes which enhance factor productivity will be introduced more slowly. Further, if innovative activity is encouraged and financed by prospects of gains realized ultimately through commercially profitable applications, then slowing the anticipated rate of diffusion would also adversely effect the pace at which new technological opportunities will become available for adoption. The feedback loop through endogenously controlled diffusion cannot prevent unemployment and labour market disequilibria arising from rapid technological advances, but it will moderate them and transmute these costs of change into economic costs of other sorts, which are likely to be distributed rather differently among the members of society.

I must turn at last to the second set of considerations that bear upon the short-run outlook, those influencing the ability of factor markets to cope with transitional disequilibria. Here it may be remarked that the new information technologies which are the subject of discussion may have a beneficial effect if they are more widely applied to the problems of monitoring local labour market developments, pooling data on the existence of vacancies (and redundancies) in employment categories with specified skill qualifications, and computer-matching individual workers to jobs over larger areas than is now feasible. A network of computer-assisted labour exchanges would make periods of "frictional unemployment" shorter. Better information would tend to reduce the dispersion of rates of return on investment in retraining, or in labour migration, or in both. It seems obvious that public sector investment in

this area should be re-examined in the light of these emerging technological opportunities.

On the opposite side however, one must avoid basing unwarranted optimism upon the large scale reallocations of labour and capital that have been achieved in the market economies of the West during the post-Second World War boom. For the macro-economic picture is much gloomier presently than anything which industrialised nations as a group have known during the past twenty-five years. When employment demand contracts to levels that imply substantial margins of labour redundancy, the savings of workers who are on short-time or unemployment assistance begin to be depleted. But it is largely from such savings that workers must (internally) finance general job-training, or retraining to permit relocation to occupations and geographical locales where excess labour supply conditions do not prevail. Weak growth of demand and dwindling profit margins also sap the resources from which firms may (internally) finance specific job-training programs, and new technology-embodying investments that help maintain their competitive position. Indeed, it appears that because necessary software development and the training of workers in computer-aided design and manufacturing processes are difficult to finance externally, investment in micro electronics equipment itself may be more cyclically sensitive than might be supposed by those who consider only its productivity-enhancing effects.

Demand-constrained firms behave more like monopolists, and asset constrained workers are less likely to shift occupations and locations in response to deterioration in their earnings opportunities. It is easy to see, then, how adverse demand side developments in the macroeconomy - arising from deflationary monetary and fiscal policies - will compound structural, supply-side causes of unemployment. What otherwise would be comparatively brief episodes of technological displacement and temporary unemployment in the lives of individual workers, are more likely to degenerate into prolonged bouts of joblessness, dissaving, and growing personal and social disorientation.

In the present climate of universally retarded economic growth, intensified international competition, and rising unemployment rates in western Europe and the United States, my own opinion is that the mounting concern expressed by workers and union leaders over the detrimental short-run employment consequences of accelerated technological progress is a reaction "not founded on prejudice and error" - to recall the famous phrase used by David Ricardo.

C. STATEMENTS BY BIAC AND TUAC

DISCUSSION POINTS RAISED BY THE
BUSINESS AND INDUSTRY ADVISORY COMMITTEE
(BIAC)

Industry representatives at the meeting concurred with the general conclusions of the reports. This does not, however, mean that business necessarily agrees with all the specific measures proposed to promote or else influence the use of the new technology.

Although the results of the analysis essentially indicate positive overall effects of electronics, these positive aspects could be stated more clearly. Without disregarding potential difficulties, there are also potential benefits attached to electronics. These benefits may however be less easy to distinguish and it is essential that efforts are made to describe them at a session of this kind.

There are however a number of intrinsic difficulties if one tries to forecast in detail how new technology may be applied and to what effect. The discussion during the meeting clearly showed that the economic determinants of employment are not sufficiently understood, though they can be partially quantified. This is even more true for the social determinants of employment and the social determinants of the effects of new information technologies. For instance, our knowledge about the motivation to work, to learn and relearn, to change jobs or location is scarce. This also applies to management decisions involving the motivation to hire, to invest, to innovate or to take the risk of introducing new technologies.

In addition, much uncertainty attaches to the new technology itself, what products and systems are technically feasible. As always with radically new technologies we are venturing into unknown territory where we must rely on trial-and-error.

In order to cope with this unavoidable uncertainty, governments and private enterprises must remain flexible. Government could play a constructive role by setting a framework for action rather than by prescribing

specific actions. The principles of a market economy, responsibility for the broad educational needs and the infrastructure for the new information technologies, like telecom networks, are important factors in such a framework.

Research and Education

Education is a central area where Governments have prime responsibility. Governments should respond more quickly to the need for introducing education concerning data technology and electronics, particularly in youth training programmes and at university level. Training within industry is also vitally necessary although this responsibility should remain with industry as the training programmes must be adapted to the individual needs of the company. Government, however, can help support these programmes through general measures, such as fiscal incentives for retraining.

In order to ensure the transition to electronics within industry, practical training and retraining will require a great proportion of available educational resources. Given the scarcity of teaching resources, in particular, youth education must be given high priority. Early familiarity with electronics is essential if the new generations are to use electronics efficiently. De-mystifying the new technology is a major task for the school system.

It is also necessary that Governments help to create new research openings and teaching facilities at universities. It is especially important with fast changing technologies like electronics, that the university structure permit continuous adaptation to new developments and changing educational needs. This is only possible by leaving the bulk of financial expenditure decisions to the university institutions themselves. On the other hand, government programmes must take into account the scarcity of experts in this area and must therefore avoid too strong a draw-down of industry experts to universities or to government supported establishments, like research associations.

Regarding the transfer of skills, it should be noted that many companies, who have successfully passed over into electronics, are surprised that retraining has been less problematic than foreseen.

Employment and Job Quality

It is encouraging to observe that the predicted number of job-losses in some countries, e.g., Germany, due to robotics is very low. This is particularly true

when compared to the annual turnover of the labour force in industry. It should be emphasized that many of the jobs that have disappeared are the more undesirable jobs, i.e. very strenuous or hazardous tasks. Many of the jobs forecasted to disappear will be of this character, mainly because it is no longer possible to recruit labour for these tasks but also because many of these installations are rather simple compared to the advanced systems approach needed when designing a process industry or a whole new manufacturing line.

It should also be remembered that robots and other automated equipment can provide interesting new jobs. New technology means product openings that are well suited to the experience and production facilities of the engineering industry in OECD countries, and can help contribute to employment in industries in competition with newly industrialised countries. Further, micro-electronically aided production equipment can lead to new tasks on the shop-floor since in spite of increasing facilities for self-diagnoses and self-repair, automated equipment will need considerable overhaul and maintenance.

There is furthermore a great potential for decentralising employment. Decentralisation can develop in two ways:

- Electronics make it uniquely easy to start new small firms around advanced products, and to some extent such firms could be localised in any area of a country.
- The important avenue for decentralisation may, however, be decentralised production in larger firms, which is possible when local plant overhead can be cut down by telecom co-ordination from a main plant.

Capital Productivity

BIAC would like to stress that experiences with the new technology indicate that it may also lead to increasing capital productivity. Lead times, and thus the capital stock in inventories, can be substantially lowered with automatic installations, flexible shop design, etc. This mechanism does not have directly negative effects on employment, but may ensure safeguarding of jobs through better competitiveness.

Good Working Conditions

Finally, we fully agree with a statement made at the meeting that microelectronics provides a hitherto unknown potential to adapt the working place to the

needs and wishes of an operator. No previous technology, in principle, permits this kind of flexibility, although system design skills to take advantage of this will need a long time to fully develop.

CONCLUDING REMARKS FROM THE
TRADE UNION ADVISORY COMMITTEE TO THE OECD
(TUAC)

We would not wish in our concluding remarks to concentrate on the effect of microelectronics and information technology on levels of employment. Indeed we would concur with the general consensus of the meeting that the overall employment effects will be primarily determined by factors other than technology, including questions such as government macroeconomic policy, industrial policy, trade changes and investment strategies of companies. However, the general macroeconomic climate, and indeed the strategies of governments, will determine the ultimate reaction to the technology by working people and the public in general, and the social acceptance of technology may well determine the rate of diffusion and the rate at which the benefits of change can be exploited.

We would therefore re-emphasize the fact that, against the background of stagnant world trade growth and deflationary government policies, the strategy which many governments have adopted of increasing their shares of international trade against a background of slow growth or no growth at all of domestic markets, is not a strategy which can be attained in the OECD area as a whole. Individual government policies will prove to be self-defeating at an OECD level. We would wish to emphasize the contradiction between the possibilities for growth and expansion offered by technology on the one hand and the likelihood of increasing unemployment against this overall macroeconomic background on the other.

We would also argue that deflationary policies do not provide the background for successful management of change which has been highlighted in this conference. Nor will deflation cure inflation, but it will only lead to more countries, and, as has been pointed out, to the danger of a rejection of new technology and the increasing danger of the industrialised economies becoming locked into a low-growth trap with low profitability and low investment leading to self-perpetuating constraints

upon expansionary demand management policies. Unless, in the OECD as a whole, we manage to expand investment at the same time as expanding demand and ensure that investment is of an expansive kind rather than simply for rationalisation, then there will be no possibility of breaking out of the vicious circle which OECD economies are caught in. The trade unions believe that there is a possibility for breaking out of this crisis and that involves joint action between governments and more direct government action in the field of industrial policy.

Even against an optimistic background of economic expansion for which the trade unions are calling there will be significant shifts in employment and a significant loss of jobs in certain sectors due to new technology. This has been recognised by all the speakers in the conference. Women are at risk from deskilling and an unsuitable background for retraining. Given the narrow occupational base of traditional entry level jobs for women, concentrated in retailing and clerical work, it is clear that job opportunities in these occupations are not available in sufficient numbers, as they have been in the past, to meet demand. The question is, has new technology contributed to the failure of the labour market to match supply and demand in areas of traditional female employment? Women, including young women and women returning to the work force after having families are, by virtue of their low average levels of skill and traditional narrow occupational base, likely to be adversely affected by new technology. The office and the retail outlet have been historically undercapitalised.

The potential productivity improvements are therefore quite enormous. The implications for female employment are clear, and they call for positive action to ensure that the exercise of one's democratic right to work is not denied on the grounds of sex. Basic education, vocational training and occupational counselling services must address themselves to this problem. Governments have a clear responsibility to act

In order to match training, retraining and relocation policies in government in individual countries with these changes we require improved evidence of where the changes are taking place and where jobs are being lost, as indeed where new jobs are being created and where they will be required in the future. A number of speakers pointed to the need to find out in which companies and in which sectors new jobs are being created. We see an important role for the OECD in providing a pool of information and further analysis on where jobs are being lost and where they are being created. We do not accept the general view stated, which reflects a degree of complacency, that the changes are likely to be

relatively small. We feel that they will be significant and will require counter-strategies to be prepared in advance.

In the consultants report, the possibility was raised of a wages-employment trade off. Let us say unequivocally that the trade union movement has no intention of accepting any proposal to use new technology as a means of reducing standards of living throughout the work force. We see new technology as a means of improving living standards, improving working conditions and, if we are to accept changes, there must be at least the potential to achieve full employment. To propose a trade off of wages against employment is to propose that new technology is a new instrument of oppression and exploitation. As such it is rejected by trade unions as it should be rejected by governments. We should take the advice of the speaker from Germany, and develop the positive aspects of new technology. We should seek to improve wages and aggregate levels of employment.

Quality of work

We would also wish to point out where safeguards are needed for maintaining and improving quality of work and general skill levels of those workers interacting with information technology and computer-based systems in the future. We would highlight six safeguards for the use and introduction of computers:

- 1) the limitation of specialisation and the assurance that individual workers will be given an overall view of the work process;
- 2) the limitation of time spent working with visual display units and computer terminals: an objective of four hours or less per day should be set;
- 3) there should be increased possibilities for social interaction between workers and group activities and group work within the production process;
- 4) workers should be given increased responsibility and their skill levels raised;
- 5) there should be limits over the collection of personal data and centralised collection of this information;
- 6) the benefits of new technology should be distributed in the form of reduced working time, redistribution of income, and an increased social wage.

Means of achieving these goals

There was considerable consensus in the conference upon the necessity for a positive approach to trade

union involvement, consultation and negotiation in the process of change. We see this as being a central condition for the satisfactory management of change. To this end there should be extensive and early disclosure of information by management to trade unions before new technology is introduced. This should be followed by the possibilities for consultation, access to outside advice and ultimately negotiation by the trade unions and management on the objectives and installation of the computer systems. The "systems approach", which is closely associated with computer-based systems, requires earlier intervention by trade unions in the change process than has perhaps been the case when dealing with the introduction of traditional technology. Trade unions should also become involved and have a say in the allocation of resources for industrial research and development. We would also point out that this consultation and negotiation must be real and not illusionary.

There are no short cuts to industrial democracy. Manipulative approaches will fail in the medium and long-term. However, it is not clear that all who espouse the principle of consultation do so for the right reasons or to achieve the right objectives. The trade unions do not see consultation as a means by which labour can be persuaded to accept something which is not necessarily in their best interests. It should not be seen as a process of buying off employees in order to "reduce resistance to change". Trade union members do not elect their officials to facilitate the possible destruction of their jobs. What consultation is about is ensuring that the exercise of human and social choice is not a matter of management prerogative. It is about the right of employees to influence the making of decisions which are going to effect their working lives.

Changes consequent upon the introduction of new technology are not determined by the technology but by people. Those who know how things worked before the change have a great deal to contribute to the decisions about how it will be performed in the future. How jobs will be redesigned, or how the working environment might best be constituted are matters about which workers have a right to express a view and have that view taken into account. The protection and promotion of safe and satisfying working conditions are matters about which workers have a right to express a view and have that view taken into account. The protection and promotion of safe and satisfying working conditions are matters of legitimate concern to organised labour. New technology can be used to promote the democratisation of work and the improvement of terms and conditions of employment, as is happening in many of the countries represented at the conference. On the other hand, that attitude to consultation which sees it as "reducing resistance to

change", an attitude represented by some others at the conference, is likely to arouse proper suspicion among employees, leading to increased resistance. Full and meaningful involvement of organised labour from the beginning of the process of change can provide the mechanism by which new technology can be introduced to the mutual advantage of labour and management. From the time when first thoughts are being given to change, employees or their representatives, should be fully involved and given all the information which is necessary for their involvement to be fully effective. Governments have a clear responsibility to establish frameworks within which this might happen, and to the extent that governments are themselves employers, they have an undeniable obligation to establish acceptable mechanisms for the process of consultation to occur within their administrations. The negotiation of technology agreements by governments as employers is a good place to start.

The future work of the OECD

The consensus on the consultation and negotiation on the introduction of change should be taken up in the future work programme of the ICCP. We would welcome further discussion with the ICCP Committee on how this might be developed in practice and would offer the services of TUAC, the ETUI and national trade union centres for providing information in this regard.

On the question of the role of the Committee in exchanging national information and publishing national reports, we would emphasize the refreshing and welcome approach shown in the conference of adopting a consultant's report which summarised and compared the key points of national reports and national statements. We hope that this approach will be adopted in the future, and indeed, taken further. We would support the point of view of the Austrian Delegate made in the conference that the consultant's report could usefully analyse the differing conclusions and differing assumptions of the national reports as well as simply repeating them factually. As was pointed out, we feel that a simple repetition of national statements, some of which have to be written in diplomatic language would not take us very far in our future work. We would also urge the ICCP Committee not simply to undertake future studies but to ensure that its work and the conclusions of the conference are taken account of in other parts of the OECD's activities, including economic policy, industrial policy and science and technology policy.

Part II

INFORMATION TECHNOLOGY APPLIED TO MANUFACTURE (ITAM)

A. TRENDS IN THE USE OF INDUSTRIAL ROBOTS
IN THE 80s - THE CASE OF THE
FEDERAL REPUBLIC OF GERMANY

by

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1. INTRODUCTION

This report discusses certain trends in the production and use of industrial robots and takes the Federal Republic of Germany as an example. The content of the report comes under three headings, likely to acquire increasing importance in the future.

1. Changes in the demand for industrial robots in the 80s.

The Market situation with regard to industrial robots will be very different in the 90s from what it is today and the robot industry will therefore be under constant pressure to innovate and exposed to the risks.

2. The scale of the threat to jobs.

From 1985 onwards the use of industrial robots will put certain categories of jobs at considerable risk.

3. Marketing and innovation strategies of the manufacturers of industrial robots.

In Germany the robot industry is a very "mixed bag". The outcome of the struggle between medium-sized mechanical engineering industry and the electrical engineering industry is not yet clear.

Data used in this analysis were, for the most part, not previously available. They came from a market survey(1).

Table 1 gives some figures that enable the industrial robot situation in Germany to be seen in an international context.

1. Carried out by the GEWIPLAN Company and jointly commissioned by robot manufacturers and scientific institutions.

The figures for Sweden, Japan and Germany confirm that Japan is the leading country in terms of numbers of industrial robots in use. However, in terms of density, expressed as the number of industrial robots per million workers, Sweden clearly outstrips Japan and even more so Germany.

The figures suggest that Germany will catch up with Sweden and Japan in the course of the 80s although considerably higher growth rates than those planned in Japan and Sweden will be necessary.

The figures given for Germany for 1985 and 1990 are estimates of the potential markets and therefore relate to the demand situation. The discussion of the situation in Germany will show that the materialisation of this potential market will depend not only on technical development this is also true for Japan and Sweden - but also on the building-up of an efficient robot industry. In the 70s there were considerable problems in this respect. The "use" figures for 1980 and 1981 show that these problems have become less acute.

When considering the situation in Germany it needs to be stressed that, in addition to Japanese achievements, more attention will need to be given in the future to what happens in Sweden.

2. USE OF INDUSTRIAL ROBOTS

The present potential for the use of industrial robots is a maximum of about 70,000 units. The figure indicates the number of handling operations that could be taken over, allowing for technical and economic constraints, by freely programmable units with a minimum of 4 degrees of freedom.

Only 2 per cent of this potential is being exploited at the moment. Estimates for the future are 20 per cent for 1985 (about 12,500 units) and 60 per cent for 1990 (i.e. about 39,000 units), see Table 2.

The estimates, both of potential and of widening use, depend on certain conditions:

1. Solution of the problem of control and sensor systems; mastery of these problems is especially important for assembly line use;
2. Systematic inclusion of robot technology in investment decisions, especially with regard to the replacement of existing presses and machine tools;

Table 1

GROWTH IN THE USE OF INDUSTRIAL ROBOTS IN
SWEDEN, JAPAN AND GERMANY

1. Sweden	No. of IRs	IRs per million employed
1970	55	13
73	135	31
77	490	114
79	940	219
84	2,300	535
90,94	8-9,000	approx.1,977
2. Japan	No. of IRs	IRs per million employed
1970	approx. 120	2
73	" 390	7
77	" 1,630	29
79	" 4,040	72
80	" 7,180	128
85	" 16,000	286
3. Germany	No. of IRs	IRs per million employed
1970	some experimentation	-
73	approx. 100	4
77	525	23
80	1,255	55
81	2,300	100
85/87	12,500	543
90/94	40,000	1,739

Notes: The absolute figures are taken from the different countries' reports given at the second OECD Conference on Information Technology, Productivity and Employment. The Japanese estimate for 1985 comes from the Robot Institute of America.

Numbers employed: Sweden 4.3 million (1980), Germany 23.0 million (1979) and Japan 56 million (1979).

3. Development of the necessary engineering knowhow among users and efficient sales service by manufacturers.

The following method was used to determine maximum potential.

On the recommendation of experts, 14 industries were selected (see Table 3). Each of these was then subdivided into task-specific uses for industrial robots.

Robot-relevant scores were then worked out for each individual area of use, e.g. number of assembly line positions in the electrical engineering industry, number of welding points per car, number of NC machines, number of presses, etc. Trends in these figures during the 80s were estimated.

From these figures certain deductions were made, e.g. the percentage accounted for by small concerns was deducted(2). Similarly, machines which are not likely to be replaced by new investment in the next ten years were deducted(3) as were products unsuitable for handling by robots on account of their size or weight, or which could be more economically handled by other processes. The difference between the initial score and total deductions is the maximum potential for the use of industrial robots in each specific area of use in each industry.

With this potential as a basis, an attempt was then made to make realistic estimates of the potential market in 1985 and 1990 by asking to what extent industrial robots could satisfy latent demand from the standpoint of technical performance and profitability.

This necessarily short review clearly shows the extent of the uncertainties in estimating the potential market.

Table 2 sets out the most significant results of the survey. Column 1 lists the most important areas of use compiled from all the industries covered by the study. Columns 2, 3 and 4 given actual units in use for the years 1977, 1980 and 1981; columns 5 and 6 given the estimated market potential for 1985 and 1990. To allow for inaccuracy in the estimates, it is advisable to see these last two dates as periods, i.e. 1985-1987, 1990-1994.

2. Assumed to have insufficient finance.

3. Assuming robot-compatibility in the necessary capital goods.

Column 7 gives the present maximum number of potential uses per area and column 8 the percentage exploitation of the maximum market potential for 1980 and the figures which would be achieved if the market potential were fully exploited in 1985 and 1990.

From discussion with experts on this table it appears that the importance of track welding was probably underestimated and that the degree of exploitation in the case of spot welding might perhaps increase more quickly than indicated.

In the light of the above it is possible to identify significant changes in the demand for industrial robots in the 1980s.

Four years ago, in 1977, 40 per cent of industrial robots in Germany were in use in the areas of finishing, and pressure and injection moulding. These were the two largest areas of use. This percentage will have dropped to 10 per cent by the period 1990 to 1994.

	IRs as a percentage of total IRs in use			
	1977	1980	1985-87	1990-94
Finishing	17	12	7	4
Pressure and injection moulding	23	11	6	4
Total	40	23	13	8

At present, welding is the activity in which most industrial robots are used in Germany.

	IRs as a percentage of total IRs in use			
	1977	1980	1985-87	1990-94
Spot welding	14	27	20	12
Track welding	2	11	3	1
Total	16	38	23	13

Table 2

GROWTH IN THE USE OF INDUSTRIAL ROBOTS IN THE FEDERAL REPUBLIC OF GERMANY
FROM 1977 - 1980 BY AREAS OF USE

	units of actual use						market potential				present maximum potential		degree of exploitation in %		
	1977		1980		1981		1985/87		1990/94				80	85	90
	abs.	%	abs.	%	abs.	%	abs.	%	abs.	%					
1	2		3		4		5		6		7		8		
TOOL HANDLING															
Finishing	90	17	155	12	231	10	860	7	1,720	4	1,835	5	8	47	94
Spot welding	74	14	339	27	771	34	2,450	20	4,450	11	5,500	8	6	45	81
Tract. welding	12	2	138	11	227	10	410	3	840	2	840+	1	16	49	100+
Deburring	8	2	approx. 6	1	10	-	110	1	530	1	635	1	1	17	83
Assembly	2	-	approx. 50	4	101	4	1,250	10	8,030	21	20,200	30	0	6	40
Other	5	1	36	3	59	3	85	1	375	1	550	0.5	-	-	-
Provisional total	191	36	724	58	1,399	61	5,165	41	15,945	41	29,360	43.5	2	18	54
WORKPIECE HANDLING															
Pressing	50	10	74	6+	25	1+	2,675+	21	8,050+	21	17,400+	25.5	21	15	46
Forging	28	5	24	2	29	1	350	3	900	2	1,200	2	2	29	75
Pressure injection moulding	120	23	139	11	113	5	700	6	1,725	4	3,200	5	4	22	54
Machine tools	approx. 14	3	192	15	374	16	2,800	23	10,110	26	14,350	21	1	20	70
Other	90	17	47	4	339	15	714	6	2,430	6	2,460	3.5	-	-	-
Provisional total	302	58	481	38	880	38	7,319	59	23,215	59	38,610	57	1	19	60
Development & testing	approx. 32	6	approx. 50	4	22	39	-	-	-	-	-	-	-	-	-
Total	525	100	1,255	100	2,300	100	12,484	100	39,160	100	67,970	100	2	18	58

These figures were considered by experts to be much too low.

Source: GEAH study with the hel of OPA (1977-81) and GEMPLAN data.

Note: 1. Rounding errors.
2. The figures are to be read as orders of magnitude.

* These figures were considered by experts to be much too low.

** The differences occur because more simple robots were also included in the analysis of market potential.

Approximately 38 per cent of industrial robots used today are employed for track welding and, more particularly, spot welding. Because of this high degree of exploitation the 90s will be a period replacement rather than innovation, at least in Germany.

These hitherto dominant areas of use, which will be of declining significance in the long term, contrast with other areas showing the opposite trend, namely machine tools, presses and assembly line uses.

	IRs as a percentage of total IRs in use			
	1977	1980	1985-87	1990-94
Presses	10	6	21	21
Machine-tools	3	15	23	26
Assembly	2	4	10	21
Total	15	25	54	68

With regard to the handling of work-pieces on presses and machine-tools, growth in the use of industrial robots will depend on the amount of investment in replacing these goods, assuming that the new presses and machine-tools are designed and built for robot operation.

Growth in assembly robots on the other hand will mainly depend on the solution of the familiar control and sensor system problems.

The breakdown to market potential by industry (see Table 3), confirms that robot technology is applicable to all industries though concentration is apparent in a few sectors, i.e.

- motor industry
- electrical engineering
- mechanical engineering
- earthmoving machinery

It should be pointed out that the use of industrial robots will not be limited to the 14 branches listed. It is known that the clothing, printing and confectionery industries are considering their application

and in some cases are actually planning their introduction, the areas of use being packaging and palletising.

The data in Table 2 indicate that the robot market too has a saturation point. The degree of exploitation and the respective market shares suggest that the assembly industry in particular will still have room for the introduction of industrial robots in the 90s. In the other industries replacement rather than introduction will increase in importance. Even if the tendency towards market saturation is pushed back a further ten years, i.e. to the year 2000, the domestic robot industry will have had to establish itself as an export industry if it is to avoid decline.

Some additional technical data are given here to show the required capabilities of industrial robots.

- In approximately 80 per cent of cases, units with four or five degrees of freedom will be sufficient because of the high percentage of machine-loading operations.
- In the medium term, only about 15 per cent of units will require track control.
- Extreme positioning accuracy, i.e. ± 4 mm, will only be necessary in just over one-third of cases.

From this it can be assumed that, in many cases, users' investment calculations coupled with their know-how and skills will be the deciding factor rather than scientific engineering research and development. From the point of view of the manufacturer this means that customer and maintenance service will quickly gain in importance. Even so, the largest part of the future market, i.e. assembly, will require initial research and development.

The expected development trends described above point to the conclusion that in the future the use of robots will not simply be a matter of general growth. Considerable restructuring of demand is involved which will, in turn, require the manufacturer to be highly flexible in adapting his products to greatly varying situations.

3. MARKET AND INNOVATION STRATEGY

If the above outline of trends in demand are related to certain information about manufacturers of industrial robots we find, in Germany, that:

1. there is a great variety of robot manufacturers, and

Table 3
MARKET POTENTIAL FOR IR USE BY INDUSTRY AND AREA OF USE (1985/1990)

Area of use	Tool handling												Work place handling										Σ	
	Finishing		Spot welding		Track welding		Deburring		Assembly		Other		Pressing		Forging		Pressure injection moulding		Machine Tools		Other			
	85	90	85	90	85	90	85	90	85	90	85	90	85	90	85	90	85	90	85	90	85	90		
Industry																								
Plastics							50	395					225	900			700	1725			83	370	1050	3390
Glass																					40	100	40	100
Ceramics	55	55																			13	150	68	205
Foundries							60	135							350	900					460	670	520	805
Steel shaping																							350	900
Shipbuilding																					In some individual cases			
Aerospace																								
Mechanical engineering	100	150			80	150			200	1200			450	1200					900	2600			1730	5300
Motor industry	375	930	2450	4450	200	390			350	2700			560	1800					800	3100			4735	13370
Earth moving machinery	120	200			80	200			200	650	70	150	600	1650					350	1100			1420	3950
Precision and capital engineering	50	100							80										30	110			80	290
Electrical engineering	150	200			50	100			500	3400			840	2500					800	3200			2340	9400
Woodworking	10	85									15	225									95	875	120	1185
Pulp & paper																					23	265	23	265
Σ	860	1720	2450	4450	410	840	110	530	1250		85	375	2675	8050	350	900	700	1725	2880	10110	714	2430	12484	39160

Source: GFAH study based on GEWIPLAN data.

2. no stable, forward-looking domestic robot industry yet exists.

There are about 50 different manufacturers of industrial robots in Germany, 20 of them German.

In 1977, the five largest manufacturers supplied about 50 per cent of robots in use; in 1980 the figure was over 80 per cent (see Table 4).

These global figures are misleading, however, because of the heterogeneity of the market, and it is unlikely that this concentration involving a few manufacturers will remain stable. For the most part it is due to the exceptional market for welding robots in the motor industry. A breakdown of the figures shows that Volkswagen AG accounted for one-fifth of the robot market in 1981. Volkswagen robots are mostly used by the company itself; they are not readily available on the market. Given Volkswagen's combination of robot development and use, wide application and risk testing (assembly robots), and the systematic inclusion of robot philosophy in investment planning, the company well qualifies for the title "the Japanese of Germany".

A few figures suffice to show Volkswagen's special situation(4).

IR use at Volkswagen		Percentage of all IRs used in Germany	
1980(1)	349 i.e. approx. 10%	) of total	approx. 28%
1981	478	) mechani-	" 21%
1985	950 i.e. approx. 40%	) sation	" 8%

1. The Volkswagen figures in Table 4 are low because they reflect the mid-year situation; the figures given here apply to 1.11.80.

If the robots at Volkswagen were left only the total number in use in Germany would be much smaller

4. F. Weissgerber, Volkswagen AG, Wolfsburg: Development and application of handling techniques in industrial production in: Industry, Robots and Humanisation; Work Conference at IG Metall, 15/16.11.80; Wesel-Büderich, IG Metall international publication pp. 43-44.

and, as Table 4 shows, the proportion that domestic manufacturers would account for out of total robot purchases would also be much smaller. Volkswagen robots which, as mentioned, are not yet supplied to the market, give a deceptively favourable picture of the German robot industry.

The manufacturers who supply the robot market (i.e. disregarding Volkswagen) can be split into two groups: specialists concerned with a particular sector of the market and general manufacturing aiming at a broader spectrum. TRALLFA (finishing and KUKA (welding) come in the first group; UNIMATION and ASEA in the second. The arrival of more machine feeding specialists seems likely in the future, see Table 4.

Two other factors are worth mentioning which are too new to be reflected in the statistics: the emergence of electrical firms (e.g. SIEMENS) as robot manufacturers and co-operation among a number of mechanical engineering companies mainly to be observed in the relatively untouched area of assembly.

The characteristics of the robot market in Germany are therefore these:

- both specialists and generalists are successful;
- both large concerns and medium-sized companies are making robots;
- companies in electrical engineering (increasingly) and in mechanical engineering are producing industrial robots;
- in most cases, separate companies are involved but robot-manufacturing consortia also exist.

If the various company strategies are set against the different industrial robot market sectors it can be seen that these sectors which will be very important in the 80s (assembly, machine-tool feeding, press feeding) are not dominated by any of the strategies described, see Table 4.

The variety of market and innovation strategies raises the question whether the industrial robot is an electrical or a mechanical engineering product. If the market is dominated in the long term by control and sensor systems, mechanical engineering will be subordinate to electrical engineering, but if control and sensor systems are freely available and the crucial factor is customer-specific information, mechanical engineering will be more important. This is more than a question of co-operation and competition between industries. If mechanical engineering were to lose out, whose main feature is the medium-size company, the structure of German industry - i.e. coexistence of medium-sized and large companies - would be at risk.

Table 4

MANUFACTURERS' SHARES OF THE INDUSTRIAL ROBOT MARKET IN GERMANY

Year		Mid 1980												End 1980 Mid 1981		Remarks
Manufacturer, nationality	Number of robots in use in Germany		Field of use											Share of robots in use in %		
			Tool handling						Work piece handling							
			Finishing	Spot welding	Track welding	Deburring	Assembly	Others	Pressing	Smelting	Pressure injection moulding	Machine tools	Others			
Volkswagenwerk, Germany	270	22%	-	20%	5	-	30	5	12	-	-	8	4	27	21	In-firm use, rarely available on the market
Unimation, USA	174	14%	-	30	50	-	10	23	-	-	40	16	3	27	18	Broad spectrum
Frailia, Norway	100	13%	145	-	15	-	-	-	-	-	-	-	-	12	12	Part Market domination
Industrie-Werke Karlsruhe-Augsburg (Kuka) Germany	151	12%	4	74	36	-	-	-	12	12	-	-	13	9	21	Increasing share based on welding robots in the motor industry
Anso, Sweden	86	7%	-	26	52	5	1	4	-	-	7	9	2	9	14	Broad spectrum
Feiss, Germany	66	5%	-	-	-	-	8	-	10	-	-	42	6	16	14	Emphasis on presses and machine tools
Fibro, Germany	59	5%	-	-	-	-	-	-	12	-	-	39	18			
Zahnradfabrik Friedrichshafen Germany	58	5%	-	-	-	-	-	-	-	12	6	40				
Siemens	39	3%	-	-	-	-	-	-	-	-	-	39				
Others	192	15%	-	-	-	-	-	-	-	-	-	-				Decreasing share
Total	1255	100%												100	100	Assembly not covered

Source: GRAF study based on IPA and GEMPLAN data.

A study of the data on the future potential market from this standpoint, shows coexistence of the various development trends in the 1980s is feasible without this involving the making of any long-term decisions. The development of electronics not only raises employment issues - a much discussed subject - it is also likely to have a far-reaching effect on industrial structures and the division of labour in the country.

4. EFFECTS ON EMPLOYMENT

Following this survey of IR supply and demand trends, the consequences for the employment situation need to be discussed. The approach will be to construct a model for anticipated redundancies. Redundancies are, of course, different from lay-offs; whether these also occur will depend on the economic situation of the company.

The aim of the model is, if possible, to distill discussion of the general issue of microelectronics, productivity and employment into the identification of areas that are actually threatened.

In the model, the following factors are basic to the calculation of redundancies:

- the number of industrial robots expected to be in use by 1985 and 1990, see Table 2;
- the effect of redundancies based on profitability calculations, see Appendix;
- the number of shifts per day.

The results are summed up in Table 5. Because of the time taken to recoup investment in industrial robots, single-shift use is virtually ruled out. Cases are known of three and four-shift robot use (e.g. glass industry). In the main fields in which industrial robots will be used, a two-shift system is the most common. By and large, it therefore seems logical to base the calculation on two-shift working.

The redundancy-per-shift effects are derived from profitability studies based on experience. In the case of spot and track welding it should be noted that some of the redundancies apply to peripheral activities.

In the case of assembly line redundancies, there is little experience to go on and this affects the calculation. In addition, these tasks count as jointing operations. A significant number of robots used in this field, however, will relate to auxiliary functions where few redundancy effects are to be expected.

In the basic profitability studies (see Appendix), the redundancy effects are largely based on average actual redundancies.

All in all, therefore, the figures are subject to several unknowns. If they are nevertheless accepted as a basis for discussion, about 200,000 redundancies can be expected by 1990-94, assuming that the market potential is fully exploited. About a third of these redundancies will occur by 1985-87 and the remaining two-thirds not before the latter half of the 80s.

From the overall social standpoint, and in the light of this timescale, the figures no longer seem so catastrophic. On the other hand it has to be remembered that the use of robots will be concentrated in a small number of industries.

	IRs as a percentage of total IR units in use		
	1980	1985-87	1990-94
Mechanical engineering	approx. 8	14	14
Motor industry	" 56	38	34
Earth moving machinery	" 8	11	10
Electrical engineering	" 10	19	24
Total	approx. 72	82	82

At present almost three-quarters of robots are used in four sectors of industry, i.e. mechanical engineering, motor industry, earthmoving machinery and electrical engineering. In the future this figure will increase to a full fourfifths. Within these sectors the main group affected is production workers, i.e. approximately 40 per cent of the total workforce.

A breakdown by industry of the redundancy effects shown in Table 5 indicates that if the use of IRs anticipated for 1990 already applied today, 10 per cent fewer production workers would be required. In assembly, a sub-group of production, 8-9 per cent fewer workers would be required.

For the early 70s, empirical investigations have shown that 70 per cent of actual redundancies were

absorbed by transfer to other fields and only 30 per cent left the companies, in a majority of cases not as a result of dismissal. Redundancies are thus not the same as lay-offs.

At the same time it might well be assumed that given the altered economic situation the number of internal transfers will decrease in the future.

This is all the more true to the extent that the motor industry in particular, but also mechanical and electrical engineering, are the ideal avenues for the introduction of a large number of new technological processes.

Categories of employees whose job opportunities are already reduced, such as unskilled and foreign workers, will stand a more than average chance of losing their jobs. It would be possible to quantify the risk factor for various groups, but more detailed study would be required.

This study might include the effect on employment of combinations of technologies and trends in skills. In particular, the coupling-up of industrial robots with NC machines - though still a development for the future since NC technology is also a relatively new science - shows that robot technology is perhaps simply the final stage in the disappearance of conventional skills.

The possible increase in jobs through increased competitiveness of products and the growth in jobs with robot manufacturers - frequently over-estimated - are other relevant factors.

These few comments illustrate the shortcomings of the model presented here. The significance and necessity of this kind of study must nonetheless be stressed. A more precise definition of the areas at risk is a necessary condition for the formulation of strategies to overcome the problem. The sheer size of the unemployment problems facing society as a whole makes such studies essential.

Table 5

REDUNDANCY EFFECTS BY AREAS OF USE AND NUMBER OF SHIFTS 1985/1990

Effect on employment Area of use	1985 - 87				1990 - 94				
	Number of shifts				Number of shifts				
	Redundancies per shift Ø	1	2	3	Redundancies per shift Ø	1	2	3	4
Finishing	1	860	1720	2580	1	1720	3440	5160	6880
Spot welding	4*	10200	20400	30600	4	17800	35600	53400	71200
Track welding	4*	1640	3280	4920	4	3360	6720	1080	13440
Deburring	0.5	55	110	165	0.5	265	530	795	1060
Assembly	4*	5000	10000	15000	4	32120	64240	96360	128480
Other	1	85	170	255	1	375	750	1125	1500
Pressing	2.5*	6687	13375	20063	2.5	20125	40250	60375	80500
Casting	1	350	700	1050	1	900	1800	2700	3600
Pressure injection moulding	1	700	1400	2100	1	1725	3450	5175	6900
Machine tool feeding	2	5760	11520	17280	2	20220	40440	60660	80880
Other	1	714	1428	2142	1	2430	4860	7290	9720
Total		32051	64103	96155		101040	202080	303120	404160

* Combined redundancy effect: IR plus peripheral activities.

Source: GFAH study based on GEWIPLAN data.

Table 6
JOBS AT RISK THROUGH THE INTRODUCTION OF ROBOTS

Type of job	Reference year	Steel industry, mech. engineering motor industry	Electrical engineering, precision engineering*, earth moving machinery
Workers	78	2,047.2	1,451.4
"	73	2,059.3	1,689.7
Change		- 0.6%	- 14.1%
Production	78	908.1	585.7
"	73	926.0	728.3
Change		- 1.9%	- 19.6%
Percentage of those employed	78	44.4%	40.4%
" " "	73	45.0%	43.1%
Assembly	78	264.2	237.1
"	73	260.5	289.5
Change		+ 1.4%	+ 18.1%
Percentage of production workers	78	29.1%	40.5%
" " "	73	28.1%	39.8%
Total number of redundancies)	85	32.3	19.2
through computerised robots)	90	53.4	61.3
Total number of redundancies)			
through computerised assembly)	85	2.8	3.5
robots)	90	19.5	20.7
Percentage of redundancies)	85	3.6%	3.3%
through robots in production)	90	9.9%	10.5%
Percentage of redundancies)	85	1.1%	1.5%
through robots in assembly)	90	7.4%	8.9%

* Not very relevant for robot application; included for reasons of data availability.

Source: GFAH study.

Appendix

PROFITABILITY OF INDUSTRIAL ROBOTS

On the following pages examples of pay-off times are calculated for industrial robots in various fields of use.

Assumptions:

Growth rates:	wage costs	6.5 per cent a year
	other running costs	4.0 per cent a year
	interest rate	9.0 per cent a year

Tables

- A 1: Profitability of machine-feeding robots.
- A 2: Profitability of welding robots.
- A 3: Profitability of finishing robots.
- A 4: Model-based calculation of the profitability of assembly robots.

Table A1
PROFITABILITY OF INDUSTRIAL ROBOTS FOR MACHINE FEEDING

Characteristics	Loading/unloading of machine tools				Loading/unloading of steel shaping machines				Loading/unloading of plastic injection moulding machines			
	Simplest machine lowest price category, no sensors, 1-2 standard grips		Machine with at least 5 axes medium price category, special type of grips, no sensors		Simplest form of industrial robot, grip specific to part, no sensors, no transfer moulding device		Machine with 5 axes medium price category, multiple grip with transfer moulding device, no sensors		Simple machine in lowest price category, no automatic visual examination, cleaning, etc., flexible grip set according to catalogue		Machine with 5 axes, simplest sensors for monitoring and cleaning of mould	
Number of machines	Single machine application		Multiple machine application		Single machine application		Multiple machine application		Single machine application		Multiple machine application	
Number of shifts	1	2	1	2	2		2		2	3	2	3
Industrial robot	35,000	39%	180,000	53%	42,000	47%	175,000	54%	45,000	61%	135,000	60%
Grip and accessories	6,000	7%	15,000	4%	10,000	11%	30,000	9%	5,000	7%	10,000	4%
Peripherals	20,000	22%	60,000	18%	15,000	17%	45,000	14%	8,000	11%	20,000	9%
Installation, machine fitting	15,000	15%	40,000	12%	7,000	8%	35,000	11%	6,000	8%	21,500	10%
Planning costs	10,000	11%	35,000	10%	10,000	11%	30,000	9%	7,500	10%	30,000	13%
Programming costs	2,000	2%	7,000	2%	2,000	2%	7,000	2%	500	1%	6,000	3%
Training	5,000	3%	5,000	1%	5,000	5%	5,000	2%	500	1%	5,000	1%
Total purchase costs	89,000	100	340,000	100	89,000	100	327,000	100	74,000	100	225,000	100
Wage cost savings	40,000	80,000	100,000	200,000	85,000		210,000		40,000	60,000	80,000	120,000
Number of employees	1	2	2.5	5	2		5		1	1.5	2	3
Skills	average		various		average		average		average wage earners		average wage earners	
Maintenance and upkeep	6,000	8,000	17,000	22,000	10,000		25,000		2,000	3,500	3,000	4,000
Conversion	5,000	10,000	5,000	10,000	5,000		7,500		2,000	3,000	2,500	3,000
Interest on capital	8,900	8,900	34,000	34,000	8,900		32,700		7,400	7,400	22,550	22,550
Pay-off period	4.5 yrs	1.75 yrs	7.25 yrs	2.5 yrs	1.5 yrs		2.25 yrs		2.5 yrs	1.5 yrs	4.25 yrs	2.5 yrs

Source: GFAH study based on GEMIPLAN data.

Table A2

PROFITABILITY OF INDUSTRIAL ROBOTS FOR WELDING

Characteristic	Spot welding of sheet metal casing				Track welding of vehicle parts (without sensors)	
	Spot welding machine with welding tong, welding tong cleaning system, and accessory multi-station welding jig, medium price category				Industrial robot with CP control without any tracklag or linking systems; simple straight welding seam on medium gauge sheet	
Type of feeding	manual		automatic		manual	
Number of shifts	1	2	1	2	1	2
Industrial robots	235,000	42%	235,000	38%	185,000	33%
Welding tools and accessories	50,000	3%	20,000	8%	30,000	5%
Peripherals (welding jig)	155,000	35%	200,000	33%	230,000	4%
Installation	48,000	6%	60,000	10%	55,000	10%
Planning costs	30,000	8%	45,500	7%	40,000	7%
Programming costs	9,000	4%	15,000	2%	15,000	3%
Training	3,000	2%	9,500	2%	5,000	1%
Total purchase costs	530,000	100%	615,000	100%	560,000	100%
Wage cost <i>Savings</i>	180,000	230,000	210,000	420,000	180,000	360,000
Number of employees	4	8	4.5	9	4	8
Skills	Skilled welders					
Maintenance and upkeep	12,000	13,000	18,000	45,000	20,000	25,000
Conversion	6,000	15,000	9,500	15,000	6,000	8,000
Interest on capital	53,000	59,500	61,500	61,500	57,000	57,000
Pay-off	4.75 years	2 years	5 years	2 years	5.5 years	2.25 years

Source: GFAH study based on GENIPLAN data.

Table A3

PROFITABILITY OF INDUSTRIAL ROBOTS FOR FINISHING

Characteristic	Spray painting (conventional)		Spray painting (electrostatic)		Finishing of mouldings	
Type of machine	Spray painting robot in medium price category		Spray painting robot in medium price category more expensive peripherals because of higher level of automation in feeding aspect of electrostatic finishing systems		Industrial robot with 5 axes, greater load capacity required, special grip releases, no sensors	
Number of shifts	1	2	1	2	1	2
Industrial robots	245,000	71%	245,000	56%	225,000	65%
Painting device and accessories or grip	9,000	3%	15,000	3%	7,500	2%
Peripherals	50,000	14%	125,600	29%	65,000	19%
Installation	10,000	3%	18,000	4%	12,500	4%
Planning costs	18,000	5%	22,000	5%	30,000	9%
Programming costs	9,000	8%	9,500	2%	2,500	0.5%
Training	5,000	1%	4,500	1%	3,000	0.5%
Total purchase costs	346,000	100%	438,000	100%	345,000	100%
Wage cost savings	55,000	110,000	55,000	110,000	78,000	156,000
Number of employees	1		3		2	4
Skills	Higher wage category		Higher wage category		Part-time workers	
Other benefits (higher productivity, material savings)	18,000	36,000	18,000	36,000	19,500	39,000
Maintenance and upkeep	15,000	20,000	15,000	18,000	9,500	15,000
Conversion (Programming)	7,000	9,000	7,000	9,000	2,000	4,500
Interest capital	34,000	34,000	43,800	43,800	34,500	34,500
Pay-off period	10 years	4.25 years	>10 years	5.5 years	6.5 years	2.5 years

Source: GFAH study based on GENIPLAN data.

Table A4

MODEL-BASED CALCULATIONS FOR PROFITABILITY OF ASSEMBLY ROBOTS (AS THE BASIS OF PILOT TESTS BY A FOREIGN MANUFACTURER)

Characteristics	Case 1a	Case 1b	Case 2a	Case 2b	Case 3a	Case 3b	Case 4a	Case 4b
Description	Assembly with two single machines with joint control and no sensors		Assembly with four single machines and joint control without sensors		Assembly machine in 1 station, 2 arcs, tactile sensor system		Staple machine for feeding and arranging (assembly aid)	
Number of shifts	1	2	1	2	1	2	1	2
Industrial robots	250,000	42%	375,000	41%	240,000	53%	40,000	44%
Grip and accessories	18,000	3%	36,000	4%	100,000	22%	12,600	13%
Peripherals	210,000	35%	320,000	36%	55,000	8%	20,000	22%
Installation	35,000	6%	65,000	7%	20,000	4%	5,000	6%
Planning costs	48,000	8%	55,000	6%	40,000	9%	8,000	9%
Programming costs	24,000	4%	45,000	5%	15,000	3%	2,000	2%
Training	10,000	2%	10,000	1%	7,500	2%	3,000	3%
Total purchase costs	595,000	100%	906,000	100%	457,000	100%	90,000	100%
Wage cost savings	115,000	230,000	150,000	300,000	115,000	230,000	25,000	50,000
Number of employees	8	8	5.2	10.4	8	8	1	2
Skills								
Part time workers								
Maintenance and upkeep	10,000	13,000	18,000	24,000	12,000	16,000	4,000	6,000
Conversion	15,000	15,000	27,000	27,000	15,000	15,000	4,000	5,500
Interest on capital	59,500	59,500	90,600	90,600	45,750	45,750	9,000	9,000
Pay-off period	>10 years	4.25 years	>10 years	5.5 years	9 years	3 years	9 years	3 years

Source: GFAH Study based on GEWIPLAN data.

B. THE PROMOTION OF ROBOTICS AND CAD/CAM IN SWEDEN

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I. INTRODUCTION

I.1. BACKGROUND

The shift from belt-driven to electric-motor-driven machinery is an example of a major technological change in manufacturing that has brought forward spectacular improvements in productivity. For about a decade now another important shift, perhaps the most significant since the beginning of the industrial revolution, has been evolving at an every-accelerating pace - the shift from rigid mechanised to flexible automated manufacturing. The major force driving the new manufacturing technology is the rapid advancement of computer and microelectronic technology.

Despite these rapid advances of computer technology, however, the process of developing the new computer-aided manufacturing technology is evolutionary rather than revolutionary. During the 60s and 70s the automation effort was directed towards various stand-alone machines. Industrial robots (IRb), machine tools (NC)(1), material-handling equipment etc., began to be equipped with programmable control systems with a rapidly increasing degree of sophistication. Now that the wide diffusion of these machines has started to pick-up, the main target for the automation effort is to integrate various machines into larger and larger systems. This is a very complicated process which requires large investments in both capital and new management and technical skills. At the same time the greatest opportunities for productivity improvement lie in optimally interconnecting various processes into computer-integrated manufacturing systems.

In the engineering industries, and especially those subjected to strong international competition (automotive industry, computers and telecommunication, consumer electronics, household appliances etc), systems integration is regarded as the key to survival in the 80s.

1. The abbreviation NC will be used for both numerical control and computerised numerical control.

Given the economic problems that most industrialised countries now face, productivity improvements are a main target of industrial policies. For this reason both Sweden and other countries have given high priority for promoting the development and the diffusion of IRb and computer-aided design/manufacturing (CAD/CAM) technology.

I.2. NEW MANUFACTURING ORGANISATIONS

I.2.1. Background

New manufacturing technology is not just a matter of highly efficient computer-aided machines. In fact, it is more a matter of developing new principles for organising the manufacturing process.

The objectives behind the new manufacturing principles are twofold:

- a) New manufacturing organisations can increase productivity without any new investments in hardware. Through shorter inventory cycles, lead times, set-up times etc. there are great potentials for improving both capital productivity and cash flow.
- b) New manufacturing principles are often required in order to maximise the potential benefits from CAD/CAM.

Mixed batch manufacturing is often described as "an activity of organised chaos": constantly changing mixes of products, components, material, batch sizes, available machines and operators, urgency of order, inventory etc. The essence of manufacturing management is therefore to solve one "crisis" after another, using the solution most expedient at the time. In this context the computer has become the most important tool (but not the solution) to bring order out of this chaos.

Manufacturing management, such as process planning and material requirement planning (MRP), is particularly suitable for computerisation because it deals mainly with collecting, processing and distributing information. For this reason manufacturing management and overall company management, including office administration, soon became prime targets for computerisation. However, many systems for computer-aided process planning (CAPP) and material requirement planning (MRP) failed to generate the results that management had been led to expect. Even if there were technical deficiencies in the systems, the main reason for the failures

were that too much emphasis was put on the tool (that is, the computer system) itself and not on how the tool should be used. Translations from manual systems into software did not work for the simple reason that the formal manual system did not work in the first place. Instead companies used informal ad hoc systems where the rules could be changed rapidly to handle the many unpredictable day-to-day events on the factory floor. These flexible but unstructured methods of management were never picked up in the computer model. The companies ended up with a rigid computerised system which did not reflect the true manufacturing process.

Another reason for the failures was that the required input and output data often were neither timely nor accurate.

The experiences from computerised manufacturing management and factory automation are clear. The main barriers and bottlenecks stem not from hardware and computer software but rather from the organisational structure of manufacturing. Much effort is therefore now being directed towards learning more about the manufacturing process in order to develop more realistic stimulation models.

1.2.2. Product-oriented manufacturing

During the 70s inventory reduction has become more and more a prime target for industrial productivity programmes. This is by no way surprising if we consider that the value of the inventory (supplies + raw materials + work in process + finished goods) in the Swedish engineering industry is twice the value of all machines and buildings. By adopting new production methods, including computerised inventory control systems. It has been possible to reduce inventory by 25 per cent or more. The increased importance of a faster inventory turnover is also reflected in the new methods of organising batch production.

For a long time the functional layout in batch production, that is, all machines of the same kind are gathered in groups, has been as natural as the transfer line in mass production. Through the functional layout, machine utilisation can be kept high, but at the expense of complex routing of parts through the shop and large buffers and inventories.

Lead time is defined as the total time needed for material to be processed into a finished product. The lead time is thus the sum of net processing time and waiting time. In batch production with functional

layout the ratio of net processing time to waiting time is usually one to some hundreds, or sometimes one to some thousands. Thus, it is much easier and far more efficient to try to reduce waiting time, which is a process that does not add any value to the product, than to increase the processing speed by more sophisticated manufacturing techniques.

In the new manufacturing methods the main principle is to organise the factory according to product oriented layouts. All machines needed to produce one product or one set of products are grouped together in a "sub-factory", sometimes with its own administration. Each worker in product-oriented layouts attends several machines. In the functional layout we can with some simplification say that the materials wait for the machines while the machines in the product-oriented layout wait for the materials. The lead time can thereby be reduced dramatically. For instance in the middle of the 70s one sector in the Swedish electrical company ASEA switched to product oriented layout. This resulted in a reduction of lead time from 6-8 weeks to one hour.

The recent increase in interest rates has tended to raise even further the relative importance of a more rapid inventory turnover.

I.3. OBJECTIVES

In this paper, policy recommendations for promoting IRb and CAD/CAM in Sweden will be presented. As a background to these policy recommendations the paper also briefly penetrates the following items:

- a) a quantitative analysis of the diffusion of IRb, NC-machines, CAD and "systems for production with limited manpower" (PLM) during the 70s;
- b) forecasts for the 80s;
- c) motives and effects of investments in CAD/CAM;
- d) barriers preventing a wide diffusion of CAD/CAM to industry as a whole.

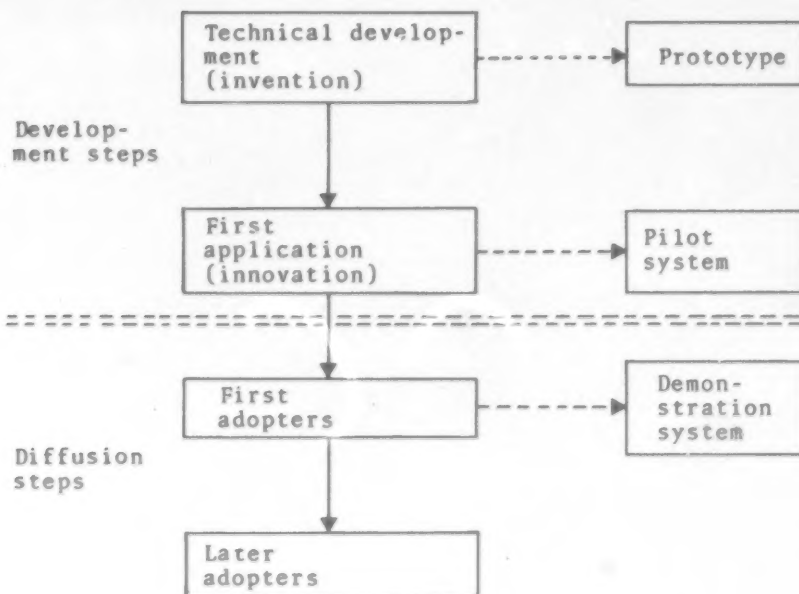
II. METHODOLOGY

II.1. THE DEVELOPMENT AND DIFFUSION OF NEW TECHNOLOGIES - A MODEL

The process of development and diffusion of a new manufacturing system is modelled in figure 1.

Figure 1:

THE STEPS IN THE DEVELOPMENT AND DIFFUSION OF A NEW MANUFACTURING SYSTEM



Source: Computers and Electronics Commission

The first step in the diffusion process is technical development. This is the inventive activity, often performed in industrial laboratories. The outcome is a technically functioning prototype. The second step is first application of the new system. We may call this an innovation to indicate the commercial function; that is, a new system adapted to industrial needs. Another term is pilot system.

The actual diffusion of new manufacturing process among potential user firms is generally a protracted process. Lags of 20-25 years between first and last adopters are common. We have divided the diffusion process into two steps; first diffusion and wide diffusion. The reason for this is that the first adopters - the technically leading-edge producers - exercise a strategic role in determining the speed and direction for the subsequent diffusion. The results and experiences from first adopters may serve as important information to alter adopters, thus reducing their risk. Therefore the systems of the first adopters may be termed demonstration systems.

The leading-edge companies are watched by a second group of fairly technically and financially advanced companies. If the leaders successfully apply the new technology it will soon be diffused to the companies in the second group. From this group the technology will then successively be diffused to industry as a whole via a third, fourth.. etc. group of companies.

The aim of increased productivity in industry is realised primarily through the wide diffusion. The leading-edge companies are important because they start the diffusion process. But it is the speed of the wide diffusion that determines what productivity gains can be achieved on an industrial level.

II.2. LEADING-EDGE TECHNIQUE ANALYSIS

In order to quantify the diffusion process of IRb and CAD/CAM we conducted a survey of the engineering industries in 1979. The survey was carried out in the following way:

1. The development of the total stock of NC-machines and IRb until 1976/1977 was known from previous surveys. On the basis of these previous studies, the companies in the engineering industries were classified into the following three groups:

- I. CAD/CAM leading-edge companies.
 Subgroup Ia: 5 top CAD/CAM leading-edge companies.
 Subgroup Ib: 16 other CAD/CAM leading-edge companies.
- II. Non-leading-edge companies that in 1976/77 were using NC-machines and/or IRb.
- III. Other companies in the engineering industries with no NC or IRb installations.

2. Questionnaires were sent out to all companies and their establishments in group I (the 22 companies in group I have well over 100 establishments in Sweden). In group II and III a stratified sample of companies was selected (the sample was stratified according to employment size and industry sector, i.e. machinery, automotive, metal working etc.). The response rate was 98 per cent.

3. In the questionnaires the companies gave information regarding the present stock (1979) and planned stock in 1984 of:

- NC-machines
 - thereof machining centres
- IRb
- CAD (number of systems and value of total accumulated investments in software and equipment)
- Systems for production with limited manpower

4. From the information in the questionnaire we could further subdivide the companies in Group III, that is companies which by 1976/77 had not yet invested in IRb and CAD/CAM. The following three subgroups could be identified:

subgroup IIIa: companies which had invested in IRb or CAD/CAM during 1976/77-1979

subgroup IIIb: companies which planned to invest in IRb or CAD/CAM during 1979-1984

subgroup IIIc: companies which did not plan to invest in IRb or CAD/CAM.

With the data collected in this study we were able to quantify the diffusion process until 1979 and forecast the development until 1984.

II.3. SUPPLIER STUDIES AND OTHER ANALYTICAL APPROACHES

In order to supplement and examine the validity of the end-user studies we also collected data from other sources. The approaches of these studies are discussed briefly below.

1. Supplier interviews. Questionnaires were sent out to all suppliers of IRb and control units for NC-machines on the Swedish market. Information was collected regarding production, export, import and domestic supply, in terms of value and number of units, for the period 1970-1979 and forecasts for 1980-1985. The forecasts of IRb and NC-machines from the supply side differed less than 5 per cent from the corresponding forecasts from the demand side.

2. In 1979 a survey of installations of IRb and NC-machines was undertaken in order to examine the nature of the manufacturing process related to these installations(1). A random sample of 26 companies were taken from the group I and II companies described above. Data were collected regarding:

A. the goods manufactured

- kind of goods
- nature of the market
- production of volume (number of units/year)
- product family size

B. the part passing through the machine

- kind of part and its function
- operation complexity, measured in min/unit
- number of variants
- number of machine reprogrammings per week
- batch size

3. In-depth studies of six Swedish engineering companies regarding motives, problems and effects of the use of IRb and CAD/CAM.

4. Domestic and international studies (i.e. various studies by the Society of Manufacturing Engineers) forecasting the technological development.

1. This study is documented in English: Hakan Selg and Jan Carlsson, Trends in the developments of numerically controlled machine tools and industrial robots in Sweden. Conference paper presented at the Polytechnic of Central London, 14 June 1980.

5. A long term econometric model of the Swedish economy was used in order to forecast the development of investment in IRb and CAD/CAM. In this model, developed by the Ministry of Economic Affairs, we have derived a submodel relating total investments in the engineering industries to investments in IRb and NC-machines. Subject to various assumptions regarding the growth rate of the Swedish economy and the rate of substitution between conventional machinery and CAD/CAM(2) an upper and a lower level of the CAD/CAM-stock in 1990 were estimated. Naturally, forecasts for such a long time period are not very accurate. For this reason we prefer to call them "calculation examples" that are intended to show the magnitude, given certain technical and economic assumptions. Thus we do not refer specifically to the year 1990 but rather to "the beginning of the 90s".

The model has also been used to check the previously discussed forecasts for 1984. Fortunately, the model presented yielded results whose concordance with the demand and supply side forecasts were very good.

II.4. LEADING-EDGE COMPANIES

In the Swedish engineering industries six main leading-edge companies can be identified with respect to the use of IRb and CAD/CAM. These companies are: L.M. Ericsson, ASEA, Volvo, Sandvik, Saab-Scania and Electrolux. In 1979 these companies accounted for 25 per cent of the total NC-stock, 40 per cent of the total IRb-stock and for nearly 50 per cent of the total number of installed CAD-systems.

The reason why the NC-share of these companies is considerably lower than the corresponding share for IRb and CAD is that NC-technology can now be regarded as mature and thus has already started to be diffused in industry as a whole. IRb and CAD on the other hand have just begun the phase of wide diffusion.

2. We know the relationship between NC-supply and total machine tool supply for each year of the 70s.

III. THE DIFFUSION OF INDUSTRIAL ROBOTS AND CAD/CAM

III.1. NC-MACHINES

NC-technique was introduced in Swedish industry around 1960. In 1970 the total NC-stock amounted to about 500 units, see table 1.

Table 1

NUMBER OF INSTALLED NC-MACHINES IN SWEDEN 1970-1979
AND FORECAST FOR THE 80s.

Company groups	1970	1973	1976	1979	1984	beginning of the 90s
The 15 largest NC-users	340 (71%)	670 (63%)	1,170 (56%)	1,490 (41%)	2,030 (34%)	
The rest of industry	140 (29%)	390 (37%)	930 (44%)	2,160 (59%)	3,980 (66%)	
Total	480	1,060	2,100	3,650	6,010	8,000-13,000
Average yearly growth, %	30	26	20	11	7-12	

Source: Computers and Electronics Commission

During the 70s the NC-stock increased on average by 25 per cent per year and in 1979 the number of units was about 3,600.

As can be seen from table I, the use of NC-machines during the 70s was largely confined to a few large companies. In 1970, 15 companies accounted for 70 per cent of the total NC-stock. In 1979 the share for these companies had decreased to about 40 per cent. Now that the phase of "wide diffusion" has commenced, it is mainly the small and medium sized companies that account for the increase in the stock.

During the 80s the growth rate of the NC-stock will decrease. This is natural for a technique that has matured and become "a conventional" technique. There are however two other strong reasons for the decreasing growth rate:

- a) An increasing share of the NC-investments consists of machining centres, see table II, each having a capacity of at least three conventional NC-machines.

Table II

NUMBER OF INSTALLED MACHINING CENTRES IN SWEDEN
1979 AND FORECAST FOR 1984

Company groups	1979	1984	Average yearly growth, %
The 15 largest NC-users	270 (51%)	410 (37%)	7
The rest of industry	260 (49%)	690 (63%)	8
Total	530	1,100	13

Source: Computers and Electronics Commission

- b) NC-machines are successively being integrated into manufacturing systems which are operated in two or three shifts, which considerably increases the degree of utilisation.

For these reasons, growth rates expressed in terms of the number of units strongly underestimate the growth rate of the total production volume that stems from NC-machines.

III.2. INDUSTRIAL ROBOTS

Swedish industry started to invest in IRb at the end of the 1960s. By 1970 the number of IRb installed amounted to 50. At this time a very rapid diffusion of IRb was predicted. In 1972 experts claimed that by the end of the decade there would be 25,000 IRb installed in Sweden. The actual outcome was a growth rate of about 40 per cent per year on average and an installed IRb-stock of nearly 1,000 units (1979), see table III. We mention this forecast because it is a good example of how the barriers to the wide diffusion of a new technology are often underestimated. In any case, a growth rate of 40 per cent per year and a stock of 1,000 IRb is impressive. Few other investment goods can show a growth rate of similar magnitude.

Table III

NUMBER OF INSTALLED IRb IN SWEDEN 1970-1979
AND FORECAST FOR THE 80s.

Company groups	1970	1973	1976	1979	1984	beginning of the 90s
The 7 largest IRb-users	30 (55%)	85 (63%)	310 (63%)	420 (45%)	800 (35%)	
The rest of industry	25 (45%)	50 (37%)	180 (37%)	520 (55%)	1,500 (65%)	
Total	55	135	490	940	2,300	6,000-9,000
Average yearly growth, %	35	38	39	20	17-16	

Source: Computers and Electronics Commission

Like NC-machines, the use of IRb has so far been concentrated to a few large companies. The seven largest IRb-users accounted in 1979 for nearly half the total IRb-stock.

During the 80s the IRb-stock will continue to expand rapidly. The net growth rate, however, will not continue to be 40 per cent per year but rather in the order of 20 per cent. There are several reasons that justify a lower growth rate in the 80s compared to the 70s.

- (a) Growth is calculated from a much higher level of stock.
- (b) There are other automation alternatives besides general purpose IRb. No doubt there are great potentials to automate, for instance, assembly and inspection operations with sensor-equipped IRb. However, computer-aided special purpose assembly machines, redesign of products and components or new materials may in many situations be the most advantageous solution to improve the efficiency of assembly operations.

III.3. CAD-systems

During the first 70 years of the 20th century, design work was not affected by any significant technical change. The drawing-board, slide-ruler and hand-books were the main tools. While the productivity of the manufacturing process, due to new technologies, increased in the order of 1,000 per cent, the productivity increase in the design process has been estimated at only about 20 per cent.

With the computer-aided design system a technical breakthrough has occurred which promises large potentials for productivity improvements. Studies that we and others have made of Swedish industry show that the highest productivity improvements are realised in connection with new product and component design and not as a result of investments in new efficient machines.

CAD results not only in higher productivity in the design process but also, and especially through the integration of CAM, in higher over-all factory productivity.

CAD-systems were introduced in Swedish industry in the middle of the 70s. So far it is mainly big corporations, especially in the electronics industry, which have invested in CAD. In 1979 the number of CAD-system (mini- and general purpose computer systems, not desktop models) amounted to 60, representing a total investment of about Skr 130 million, see table IV.

Table IV

THE NUMBER AND VALUE OF CAD-SYSTEMS INSTALLED
BY 1979 AND FORECAST FOR 1984

Company groups	1979		1984	
	Number	Million Skr	Number	Million Skr
The 22 largest NC- and IRb-users	40	100	100	250
The rest of industry	20	30	100	175
Total	60	130	200	425

Source: Computers and Electronics Commission

About 200 CAD-systems are expected to have been installed in the Swedish industry by 1984.

III.4 SYSTEMS FOR PRODUCTION WITH LIMITED MANPOWER

Definition: Systems for production with limited manpower, abbreviated PLM, have the following characteristics.

- a) A manufacturing system or cell, usually built up around a machining centre or a line of NC-machines served by IRb and/or a computer-aided material-handling system.
- b) The system can be operated unmanned or with limited manpower during the night shifts or parts of these shifts.
- c) The manual work is carried out mainly during day-time and at time points independent of the machine cycle.
- d) Total investment costs exceed SKr one million.

The last characteristic is imposed in order to exclude very simple and small PLM-systems. Even so, the PLM-systems we have registered vary considerably in size, costs and in their degree of automation and flexibility. Our quantification of the number of PLM-systems should therefore only be used as an indication of magnitude.

We also want to stress that PLM-systems are not equivalent to flexible manufacturing systems (FMS).

PLM-systems can but do not need to be flexible. The computer control is used mainly to automate certain machine-operator functions and not for flexibility reasons, in the sense that the systems should be able to handle several different components and work pieces with a minimum set-up time.

Given these restrictions we have estimated the number of PLM-systems in Sweden at 250 in 1979 (as compared to the number of machining centres, which was 530 in 1979). By the middle of the 80s we have estimated that the number of PLM-systems will have increased to about 500. Again we want to stress that the "numerical comparison" is of limited value. A system from, say, 1985 will probably be much larger and more advanced than a system from 1979.

IV. MOTIVES AND EFFECTS

A motive represents the ex ante form of an effect. However, we know that when action is taken from a set-up of motives, the resulting set-up is seldom identical.

The divergences between motives and effects may take two forms. Either our motives are not accomplished - we fail to attain our specific objectives - or we cause effects that were never thought of beforehand. In general, these unexpected effects are indirect - or secondary, which makes them difficult to foresee. Moreover, the secondary effects are not confined to the decision unit, i.e. plant or the firm, but touch upon society as a whole through competitors, clients etc.

An analysis of the motives, effects and divergences between the two, provides a base for our understanding of the diffusion of new technologies in industry. In this chapter we shall therefore list a number of common motives for adopting CAD/CAM-methods, and then discuss the nature of their effects. In this discussion we will distinguish between direct and indirect effects at plant level, as well as indirect effects at macro level. Failure to achieve a motive or a set-up of motives will be discussed in chapter V.

IV.1. MOTIVES

1. Increase productivity and thereby profitability.
This can be achieved by increasing
 - labour productivity by substituting machines for human labour
 - capital productivity by reducing lead times and speeding up inventory turnover.
2. Improve the conditions of work
3. Improve precision and tooling complexity.
4. Acquire experience from new technologies.

5. Reduce consumption of energy and raw materials.
6. Create capacity reserves.

IV.2. EFFECTS AT PLANT LEVEL

IV.2.1. Labour

Mechanisation and automation mean that less human labour is needed in the direct manufacturing operations. Instead there is an increasing need for the back-up functions of the complex technologies, which we may call indirect manufacturing work.

The organisation of work is a key determinant of various important dimensions of work; i.e. job profiles, skill requirements, wage systems etc. There is also a close relation between the manufacturing technology chosen and the organisation of work. However, technology is not the single determinant, so there is no specific organisation corresponding to the use of a CAD/CAM-system. Organisation philosophy has a predominant role, for example if one believes in complementary specialisation of skills or in overlapping skills. The CAD/CAM may be a loyal servant to any work organisation, provided that those who design and adapt the system know what they want.

IV.2.2. Capital

There is no unique impact of CAD/CAM on the requirements of capital. Certain plants have reduced their investment expenditure by replacing conventional machine-tools by NC-tools. This is possible when the difference in capacity between NC-machines and conventional equipment is superior to the difference in price.

It seems, however, to be more common for CAD/CAM to increase investments. In particular this is the case when a CAD/CAM-implementation is associated with the passing from functional organisation to product-oriented organisation. Here one important aim is to reduce lead times by holding a certain excess capacity in machines. Consequently, inventory investments tend to decrease, and if this reduction exceeds the increased investment in CAD/CAM-systems, the productivity of capital has improved.

IV.2.3. Product

Traditionally, increased productivity has to an important degree been achieved through product and component standardisation. Although computer-based technologies will modify this rule somewhat, the mainstream tendency remains. The growing use of automated processes always implies an increased standardisation. This may create confusion, as CAD/CAM is often referred to as "flexible automation". It is also true that the new technologies offer an extended flexibility in comparison with conventional automation, thus widening the range of automated manufacturing. However, compared to manual methods, CAD/CAM brings about a considerable rigidity, hence calling for increased standardization.

It is important to note, however, that the computer support itself is not the determinant of this tendency. Methods shortening lead times, standardising design and components would appear even as great without the computer. However the computer aid is reinforcing this development.

But there are other tendencies. By reducing lead times and lags for process and material planning by computer-based technologies, improved conditions for custom designed products are created. In the confrontation between market requirements for diversification and production economy requirements, industry tries to solve the problem by assembling the greatest possible variety of products out of as limited a number of standardised components as possible.

IV.2.4. Cost structure

We know from various industries - cash registers, watches and telecommunications - that a change in manufacturing technology, combined with or produced by a radical change in technical design of the product, may bring about rapid and thorough effects on cost structure.

However, as long as the product design essentially remains unchanged, advanced manufacturing systems are not likely to affect cost structures very much in the short run. No drastic impact on competition and industry structure is to be expected. This conclusion should not be surprising, taking into account that in modern industrial production, a relatively small part of

the value added of a product refers to factories with high chimneys(1).

In the long run, the accumulated effects of gradually installed systems may be important. These effects should be most painful to firms that have not updated their technology.

IV.2.5. An example

The following example illustrates the potential effects of new manufacturing technology and organisation. A Swedish company in the household appliances industry invested in a robot line for parts manufacturing.

Example

	Conventional line	Robot line
Number of operators	28	6
Floor space	1,700 m ²	300 m ²
Lead time	3-4 weeks	4 minutes
Investment costs	4,5 million Skr	8,5 million Skr
Savings through shorter lead time		0,9 million Skr
Pay-off time		1,5 year

It is worth noting that the savings obtained through shorter lead time were not foreseen ex ante in the investment plan.

IV.3. EFFECTS AT MACRO LEVEL

IV.3.1. Industrial structure

The new technology will affect industrial structure through its impact on the cost structure of the single

1. In a plant producing electronic typewriters, direct manufacturing cost amounted to 33 per cent out of value added of the plant. Process planning was 51 per cent and supervising maintenance, quality control and
- (Continued on next page)

firm of plant. First there will be an impact on the size structure of industry. As we shall see in the next chapter, the use of computer-based systems is connected with various skill and financial requirements. Firms possessing financial resources and superior technical staff - in general larger firms - will be favoured.

Optimal production volume will also be affected, but not necessarily only to the benefit of major plants. However the new technology will bring about a reorganisation of manufacturing between different plants, i.e. between a producer firm and its subcontractors.

Along with increased specialisation, the business relations between firms tend to become closer and more specific. To given an example, automated processes often require a higher degree of quality homogeneity in input material than manual methods. In metalworking industries, the use of CAM may thus necessitate investments in the steel mill. Another example is that a change in product design is often made in close co-operation with major suppliers of components. In the same way, new complex production systems as CAD/CAM tend to reinforce the mutual dependence between system suppliers and user firms.

IV.3.2. Labour market effects

In accordance with recent labour market theory we will

- make a distinction between internal and external labour markets
- consider the overall labour market as composed of different market segments.

When an organisation makes recruitments among those already employed, we talk of internal labour markets. External labour markets refer to the situation when people are recruited outside the organisation. One fundamental attribute of internal labour markets is that the required skill is plant specific to an important extent. Internal training thus plays an important role, as does the socialisation process in making the employee fit in with the organisation.

(Note 1 continued from previous page.)
stock-holding amounted to 16 per cent. It is important to note that production was the only activity of the plant. Product design, distribution, marketing, R & D and other "overheads" were performed elsewhere.

Conversely, the market conditions prevail on the external labour market. The link between internal and external labour market consists of specific introduction jobs. The internal markets are generally associated with skilled jobs, while external markets for the main part apply to unskilled or introduction jobs.

We refer to labour market segments when certain "barriers" can be observed, preventing a smooth passing from one job to another. For example, regional or professional barriers may obstruct the labour mobility.

Advanced technologies in the manufacturing process tend to increase the importance of internal labour markets. At the same time the number of unskilled, with only basic school background, moving over to the "skilled sector" is diminishing. To an increasing extent the "skilled sector" requires formal education and professional training. The vertical mobility is decreasing. Although this is a long term tendency with no particular association with computer technologies, this development is reinforced by robotics and CAD/CAM technologies.

Technical development also raises the barriers between the segments, thus reducing the mobility of labour between various segments of the labour market. As our instruments for identifying and measuring labour market movements are of no use regarding internal labour markets, the observed mobility tends to fall. Hence frictional(2) unemployment will also decrease.

We mentioned that advanced automation brings about an employment shift from direct to indirect manufacturing work. Fluctuations in the degree of capacity use due to variations in the business cycle will in the first place strike those employed in direct manufacturing. Thus cyclical unemployment will also be reduced by the new technologies.

Structural unemployment tends to increase(3). The technological speed-up stimulates structural change at

2. Even when the various market segments are in equilibrium; that is the number of applicants for jobs is offset by the number of available jobs, some time will be required for an applicant to find a job. This form of temporary unemployment is called frictional unemployment.

3. When there is a shortage of manpower in one segment of the labour market and an equivalent unemployment in another segment, we talk of structural unemployment.

(Continued on next page)

the same time as mobility between different segments is diminishing. The reduction in mobility is reinforced by increased female participation in the labour market as well as increased house-owning.IV.3.3

IV.3.3. Labour force structure

Although robotics and CAD/CAM may destroy various kinds of jobs, the predominant tendency is that unskilled jobs are replaced through automation. However, new unskilled jobs are formed by automation - or often: by failure to automate - but these jobs are likely to be temporary. By improved technology and experience the new unskilled jobs will disappear in the long run. Thus, a major effect of robotics and CAD/CAM is a diminishing demand for unskilled labour. Workshop supervisors is another professional group that will gradually lose its importance. On the other hand there is a growing demand for skilled and highly skilled labour.

Though there will be a shift in demand from unskilled to skilled labour, there is little reason to expect a smooth clearing between the two categories. As pointed out earlier the vertical mobility between unskilled and skilled jobs has in fact been reduced.

(Note 3 continued from previous page)

This unemployment will tend to disappear through "adjustment", but depending on the "height" of the barriers, as well as the existence and smoothness of adjustments mechanisms, the adjustment process may require more or less time.

V. ADOPTION OF A NEW TECHNOLOGY

V.1. INTRODUCTION

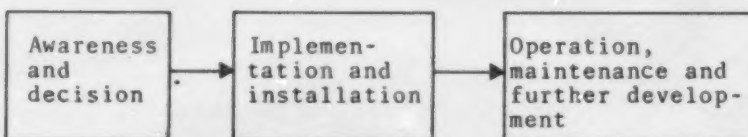
The introduction of new manufacturing systems - such as CAD/CAM - in a plant is associated with a number of difficulties. After the installation, the systems often turn out to be, if not complete failures, at least partial failures.

Productivity falls short of expectations, the new systems deteriorate work conditions, the costs of installation and implementation exceed the forecasts and so on. All this contributes - directly or indirectly - to the reduction of profitability of the system.

We shall briefly analyse of the adoption process within a firm in order to identify key factors affecting the outcome.

Figure 2

ADOPTION PROCESS WITHIN A FIRM



Source: Computers and Electronics Commission

The decision to adopt a new system is based on a number of considerations - that we may denote determinants of adoption - and an estimation of risk. The outcome also depends on the decision function, that is, who decides.

V.2. THE DECISION FUNCTION

Formally, the managing director or the members of the board are responsible for (major) investment decisions. However, when it comes to manufacturing systems, the actual decision making is to a great extent delegated to the production manager. Furthermore we may expect that a number of persons within the manufacturing activity to exert a certain degree of influence, in a more or less informal way, on system design and the decision to adopt.

Through governmental legislation in Sweden, opportunities have been created for employees(1) to influence decision making in a more organised manner. Thus the 1977 Co-determination Act and the 1978 Work Environment Act provide guarantees for employees' influence through negotiations on the design and adoption of new manufacturing systems(1).

V.3. DETERMINANTS OF ADOPTION

The considerations made when deciding to adopt a new manufacturing system cover the following aspects:

- | | | |
|----------------------|---|-----------------------|
| - Technical function |) | |
| - Profitability |) | systems attributes |
| - Financing |) | |
| - Skill |) | resource requirements |

V.3.1 Technical function

The system may not be appropriate because of lack of:

1. User adaptation. The system does not fit very well in the manufacturing process or it does not meet requirements concerning working conditions.
2. Accuracy. Lacking accuracy may cause unacceptably high percentage of scrap.

1. For a closer description, see Docherty: User Participation in and Influence on Systems Design in Norway and Sweden in the light of Union Involvements, New Legislation and Joint Agreements.
OECD/DSTI/ICCP/79.62/18.

3. Availability. Mechanical failures may cause frequent and/or lengthy interruptions. The existence of infant maladies is a major reason why technically advanced systems for long periods are not able to compete with simpler but safer methods.

V.3.2. Profitability

Despite the absence of technical deficiencies, the firm may refrain from adopting new techniques due to the lack of relative advantage compared with alternative systems. This aspect is heavily stressed in economic theory. However when it comes to practice, the ex ante calculations are often hazardous, especially regarding new systems where previous experience is lacking. Ex post calculations are seldom carried out.

We should perhaps not put too much emphasis on formal evaluations, because the "feeling" of an experienced production manager may be as accurate an indicator of profitability. Anyhow, the attitude vis-à-vis new technology - that is the conviction of its relative advantage - is probably of greater importance for the adoption than actual figures, especially in the beginning of the diffusion process.

V.3.3. Financing

Despite satisfactory profitability, financial problems may arise. Depending on the cash flow, a firm may not be able to cope with the lag between investment outlay and future return on investment. This is a general investment problem. However, in the case of computer-based technologies these lags tend to be extended due to the increased complexity of systems design, systems development and installation.

Furthermore, one attribute of investment in computer-based technology is the increased share of software in investment costs and, correspondingly, the reduced share of hardware. The software components - programmes, training, systems development and systems adaption - generally cannot serve as securities for loans. An increasing share of investment thus has to be paid out of current surplus, which tends to raise gross profit requirements.

V.3.4. Skill

A firm may refrain from adopting a new technology because of a lack of trained employees. Computer-based production technologies have brought about a radical change in skill requirements. Sufficient know-how to

project, develop and implement CAD/CAM systems is of particular importance. This process generally requires a lot of skill, experience and time. During this process the characteristics of the system are designed, in a way that the technical function of the system is good, costs are kept within forecasts and the requirements of working conditions are satisfied.

A tendency regarding computer-based technologies is the concentration of skill requirements to the early stages of the development process, as compared to earlier systems where the use of skill was more equally distributed throughout the entire life-cycle.

V.4. RISK

The diffusion of a new technology may be viewed as an adaption process under risk, where firms try to reduce the risk through a continuous gathering of information. During the diffusion process more information about the new technology is gradually becoming available, thus lowering the risk of late adopters. Lack of information exerts a restraining influence on the diffusion process.

Thus, before a decision to adopt (or not adopt) is made, information should be gathered, studied and evaluated. In this respect the crucial conditions are:

1. Relevant information exist.
2. There are channels to disseminate this information.

VI. PROMOTION PROGRAMMES FOR ROBOTICS AND CAD/CAM IN THE 80s

VI.1. BACKGROUND

In this chapter we are going to summarise the policy recommendations that the Computers and Electronics Commission has made to the Government. The objective of these recommendations is to speed up the diffusion of advanced automation - not only in the engineering industries which have been discussed here, but also in the process manufacturing industries.

The policy recommendations proposed by the Commission do not, however, mark the beginning of a completely new programme, but rather an increased level of ambition in several existing programmes. Some of these are discussed briefly below as a background to the policy recommendations which are presented in section VI.3.

The Swedish Board for Technical Development (STU) is an agency under the Ministry of Industry. STU is funding advanced R & D in universities, research laboratories and in industry. During 1972-1979 STU's funding to R & D in robotics and CAD/CAM amounted to about Skr 25 million.

During the 80s STU's support to R & D in engineering industries will increase considerably. A sum of Skr 260 million has been predicted for the period 1980/81 - 1984/85. A large share of this sum will be used for long-term projects. With respect to robotics and CAD/CAM the following long-term projects have been or are planned to be initiated:

- CAD/CAM. About Skr 14 million will be allocated to this programme during 1980-85.
- Adaptive control of machine tools. This programme will start during 1981-82.
- CAD 80. A four year joint-venture project between STU, Saab-Scania and two universities. The project cost is estimated at Skr 10 million, which is to be shared by STU and Saab-Scania.

The latter will also invest about Skr 3 million in order to commercialise the CAD/CAM-system for small and medium sized firms.

- Adaptive control of industrial robots. This programme will start during 1981-82(1).

Another major effort for promoting robotics and CAD/CAM is an R & D agreement between STU and the Swedish Association of Mechanical and Electrical Industries. According to this agreement the two parties will sponsor a five year research programme (1980/81 - 1984/85) with Skr 46 and 48 million respectively.

VI.2. WHO IS RESPONSIBLE

In a national programme for promoting the diffusion of new manufacturing technology there are several different "actors", for example the Government and its agencies and institutions. Other actors on the scene are industry, research organisations, trade unions and trade organisations. These actors have different tasks and means of promoting the diffusion of new technology. The objectives are, however, by and large the same even though opinions differ about how the benefits should be shared.

The success of a national promotion programme for new technology is very much dependent on whether the different actors are pulling in the same direction. It is not uncommon for even different government agencies to be pulling in different directions. No matter how grand a government programme may be, it will fail unless it receives some support from the other actors.

When initiating a promotion programme it is thus important to reach some degree of consensus regarding the objectives as well as the allocation of responsibility. Given the institutional framework in Sweden, the tasks and responsibilities of the different actors are as follows:

1. Similar long-term R & D programmes have been initiated for microelectronics and information processing:

- Information processing and computer science. Skr 80 million during 1980-85.
- Computerised picture data processing. Skr 19 million for the period 1979-84.
- Electronic and electrooptic components technology. Skr 136 million for the period 1979-84.

The company

The company is primarily responsible for introducing new technology and choosing what kind of technology should be used. The risks and costs are, with some exceptions borne by the company.

Trade organisation

The trade organisations' tasks, regarding new technology, are to:

- disseminate technical and economic information to its members
- provide consultation services
- arrange seminars and educational programmes
- guideline R & D efforts (industrial co-operative programmes and industrial/governmental programmes)
- promote standardization.

Research organisations

- carry out industrial and industrial/governmental research programmes in collaboration with individual companies and universities
- disseminate information from leading-edge companies to the rest of industry
- help individual companies to develop and install new manufacturing techniques.

Trade unions

Traditionally the trade unions in Sweden have taken a favourable view vis-à-vis new technology. This attitude basically remains unchanged, though it is now accompanied by requirements concerning how the technology is to be used. As mentioned, governmental legislation has given the trade unions a formal instrument to influence the introduction of new technology in a company. The trade unions are therefore an important actor for the diffusion of experiences of new technology.

The Government

Traditionally the main responsibility of the Government and its agencies has been education, from primary schools to trade schools and universities, and long term R & D. Rapid technological development, with barriers which are knowledge based rather than purely technical, has made the educational system the main bottleneck.

Other areas where the government has successively assumed greater responsibility are:

- consultant services to industry, especially small and medium sized companies
- dissemination of experiences of new technology from leading-edge companies to the rest of industry
- venture capital to small and medium sized industries
- venture capital for large applied R & D projects with high risks in leading-edge companies.

On the Swedish scene the actors discussed above are by and large of the same opinion regarding the necessity to speed up to the diffusion of robotics and CAD/CAM. The actors are also willing to take their share of responsibility in promotion programmes. As the policy recommendations from the Computers and Electronics Commission are aimed at stimulating the activities of each actor, we believe that the prospects of a joint national effort are favourable.

VI.3. RECOMMENDATIONS

1. The need for co-ordinated promotion of new technologies:

- The research institutes are given a key role in promotive activities
- Industrial organisations as well as trade unions are stimulated to diffuse available know-how and experience from new technologies among their members.

2. Promotion of long term technological development and skill at the technical faculties:

- Design and co-ordination of multilaboratory projects according to industrial policy goals - strategic projects
- Maintenance of a clear distinction between research carried out within industrial policy programmes and other academic research.

These reforms should be carried out within the limits of existing grants.

3. Promotion of R & D and technical adaptation:

- Establish regional R & D centres regarding the metalworking and engineering industries, in order to
- promote R & D co-operation between industry and university
- perform industrial R & D
- promote the diffusion of new technologies
- Establish an institute for R & D within process manufacturing industries, with the same purpose as above
- Swedish Industrial Development Fund promotion of demonstration systems, aiming at a rapid diffusion of experience and know-how
- Observance by the Fund of the strategic importance of manufacturing technologies.

The cost of establishing the R & D institutes is estimated at Skr 210 million over a period of five years. The promotion cost of demonstration systems is estimated at Skr 15 million over a period of five years.

4. Promotion of a wide diffusion of robotics and CAD/CAM:

- An information campaign among small and medium sized firms, carried out jointly by industrial organisations, the Swedish National Industrial Board (SIND) and the 24 regional Development Funds.
- Complementary software loans with conditional repayment, in order to stimulate investments in production systems among small and medium sized firms.
- Enlargement of the vocational training programme at the Swedish Institute for Corporate Development (SIFU).
- A training programme for teachers in industrial vocations with respect to computer-based production technologies.
- A training programme for 65,000 union representatives.

The costs of information and training programmes are estimated at Skr 108 million during three years. To cover the software loan facility grants should be provided to finance a fund with a capital of Skr 300 million over a period of three years.

Bibliography

PUBLICATIONS FROM THE COMPUTERS AND ELECTRONICS COMMISSION

OFFICIAL REPORTS TO THE MINISTER OF INDUSTRY

- 1) Datateknik i industriproduktionen - Förslag till
industripolitiska åtgärder. SOU 1981:59.
(Computer technology in the industrial production -
Policy recommendations. In Swedish only).
- 2) Datateknik i verkstadsindustrin - Datorstödd
konstruktion och tillverkningsteknik. SOU 1981:10.
(Computer technology in the engineering industry -
Computer aided design and manufacturing technology.
In Swedish only).
- 3) Datateknik i processindustrin - Datorstödda pro-
duktions - och processtyrssystem. SOU 1981:11.
(Computer technology in the process manufacturing
industries - Computer aided design and process con-
trol technology. In Swedish only).
- 4) Datateknik och industripolitik - Industri - och for-
skningspolitiska program inom data - och elektro-
nikområdet. SOU 1980:17.
(Computer technology and industrial policies -
Industrial and R & D policies concerning computers
and electronics in various countries. In Swedish
only).

OTHER REPORTS AND PAPERS

- 5) Industri och forskningspolitiska program inom data-
och elektronikområdet - Reserapporter från USA,
Finland, Storbritannien, Västtyskland, Japan och
Frankrike.

Ds I 1980:7.

(Industrial and R & D policies concerning computers and electronics - Travel reports from USA, Finland, United Kingdom, Federal Republic of Germany, Japan and France. In Swedish only).

- 6) Datateknik, ekonomisk tillväxt och sysselsättning - Tre uppsatser sammanställda av dataoch elektronik-kommittén. September 1980. Liber Förlag.
(Computer technology, economic growth and employment - Three papers edited by the Computers and Electronics Commission. Two of the papers are available in English).
- 7) Elektroniken i fabriken - hot eller hopp? September 1981.
Liber Förlag.
(Electronics in the factory - Threat or hope? In Swedish only).
- 8) Trends in the Development of Numerically Controlled Machine Tools and Industrial Robots in Sweden. Conference Paper. London, June 1980.
- 9) Reserapport från fjärde internationella konferensen om produktionsteknik. Tokyo, augusti 1980.
(Travel report from the 4th International Conference on Production Engineering. Tokyo, August 1980. In Swedish only).
- 10) Entwicklungstendenz bei NC-Werkzeugmaschinen und Industrierobotern in Japan. Zeitschrift für Industrielle Fertigung. Mai 1981.
- 11) The Swedish Computer and Electronics Industry - Structure and Policies. Conference Paper.
Stockholm, November 1980.
- 12) L'ordinateur au service des techniques de conception et de fabrication: Un moyen essentiel pour rationaliser la production dans les industries mécaniques. Texte de la Communication. Paris, mai 1981.

C. ROBOTISATION IN JAPANESE INDUSTRIES

by

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I. GENERAL VIEW

The use of industrial robots in Japan over the past 10 years or so has produced a number of economic and social advantages. Among them are an improvement in productivity, greater humanisation of working life, prevention of labour accidents, improvement of product quality, and early return on capital investments.

These economic and social effects stemmed from the fact that the industrial robots are flexible and versatile, featuring a greater freedom of movement similar to that of the upper limbs (arms and hand) of human beings. This has made automation of small-batch production possible, so that the introduction of industrial robots has changed the production system from a man-machine system to a man-robot-machine system. This change in the production system means that humans have been released from dangerous and unfavourable work.

II. STATE-OF-ART OF INDUSTRIAL ROBOTS IN JAPAN

The practical utilisation of industrial robots made outstanding progress in Japan throughout the 1970s, with a total of 57,000 industrial robots being in use at the end of 1979. It is predicted, however, that substantial popularisation of industrial robots in Japan will occur after the 1980s.

Production of industrial robots in Japan amounted to some yen 78.4 billion worth in 1980 and an estimated Yen 120 billion in 1981. Demand for industrial robots in the manufacturing industries in 1985 and 1991 is forecasted to approximately Yen 270 billion and Yen 520 billion, respectively.

It is expected that there will be substantial demand for industrial robots in the future in non-manufacturing industries such as nuclear energy, ocean development, and public works and construction, as well as in service trades such as medical services and transportation.

Major industrial robot users in the past are as follows:

1. The electrical machinery manufacturing industry (whose share of total distribution of industrial robots in 1980 was 36 per cent)
2. The automobile industry (29 per cent)
3. The plastic moulding and processing industry (10 per cent)
4. The general machinery manufacturing industry (7 per cent)
5. The metal working industry (5 per cent)

In addition, textile, chemical, steelmaking and shipbuilding industries are included among the industrial robot users, indicating that industrial robots are demanded in a wide range of industries in Japan. However, demand for industrial robots in non-manufacturing industries accounted for only 1 per cent of total demand in 1980, while exports stood at a meager 3 per cent of total output also in 1980.

It is expected that automation of assembling process of small-batch production in the various machinery industries will be possible in the future as the technological development of intelligent robots makes progress.

Exports of industrial robots are expected to increase substantially in next five or 10 years. However, for this to be true, Japanese makers will have to team up with overseas engineering firms, since industrial robots require highly sophisticated system engineering, prior to installing industrial robots and maintenance services after installation of industrial robots.

III. ECONOMIC AND SOCIAL ROLES OF INDUSTRIAL ROBOTS

1. Productivity Growth

Japan depends on overseas countries for most of its natural resources. Consequently, a rise in the prices of petroleum and other natural resources immediately causes a rise in commodity prices resulting in an increase in wages in the long run. It becomes imperative for Japan, therefore, to raise productivity to cope with economic difficulties, so that Japan can promote a sound and stabilised development of its economy.

In this respect, the introduction of industrial robots is expected to make automation of small-batch production of many different varieties of products possible, contributing much to an increase in productivity.

2. Humanisation of Working Life

Prevention of labour accidents and occupational diseases caused by dangerous and heavy labour, as well as by inferior working environments, is an important task for the improvement of social welfare.

In Japan, particularly, creation of a qualitative and comfortable working environment becomes an urgent necessity, due to the tendency toward a highly educated society and a growing number of white-collars workers on the job site of the workshop. No stabilization of employment can be expected without a better working environment.

A change in the production system, from the man-machine system to the man-robot-machine system, through the introduction of industrial robots, is certain to contribute much to the humanisation of working life as well as to the betterment of labour welfare.

3. Elimination of Skilled Labour Shortages

Since a growing number of people are continuing school to a higher grade in Japan, a shortage of skilled labour has been becoming more serious. It is expected that industrial robots will be increasingly utilised to solve the skilled labour shortage.

4. Contribution of the Development of New Energy Sources and Industries

It is believed that an increased utilisation of industrial robots in such new industries as nuclear energy and ocean development will contribute to the development of these industries, revitalising the nation's industry and creating new employment opportunities.

5. Others

The utilisation of industrial robots is expected to contribute further to the stabilization of product quality, the lessening of defective products, early return on capital investment through an increased rate of operation, and the improvement of production management.

IV. CONCLUSION

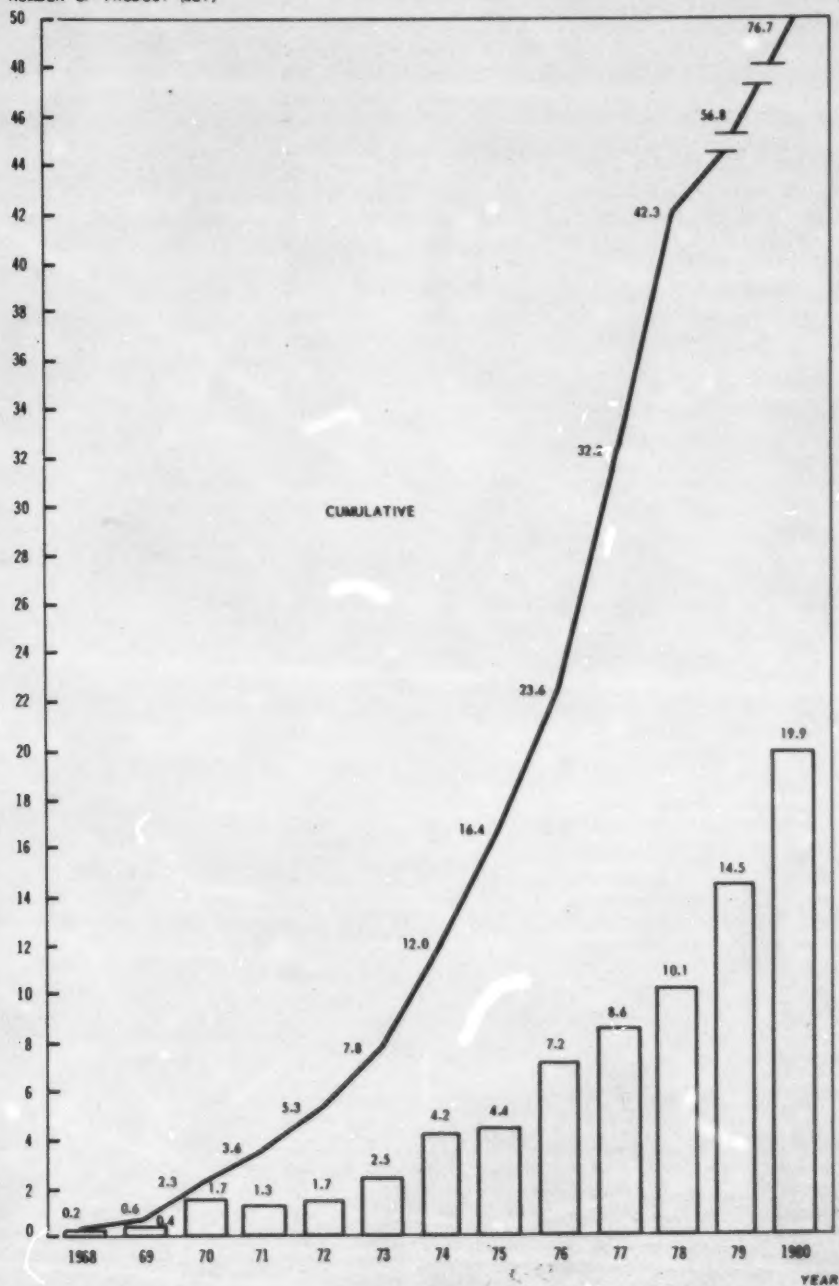
Automation of mass-production systems was the main current of industry up until the 1970s; however, the predominant trend in and after the 1980s will be

automation of small-batch production of many different varieties of products, or flexible automation of the production system. The technological development and utilisation of industrial robots is expected to form the nucleus of the new production system.

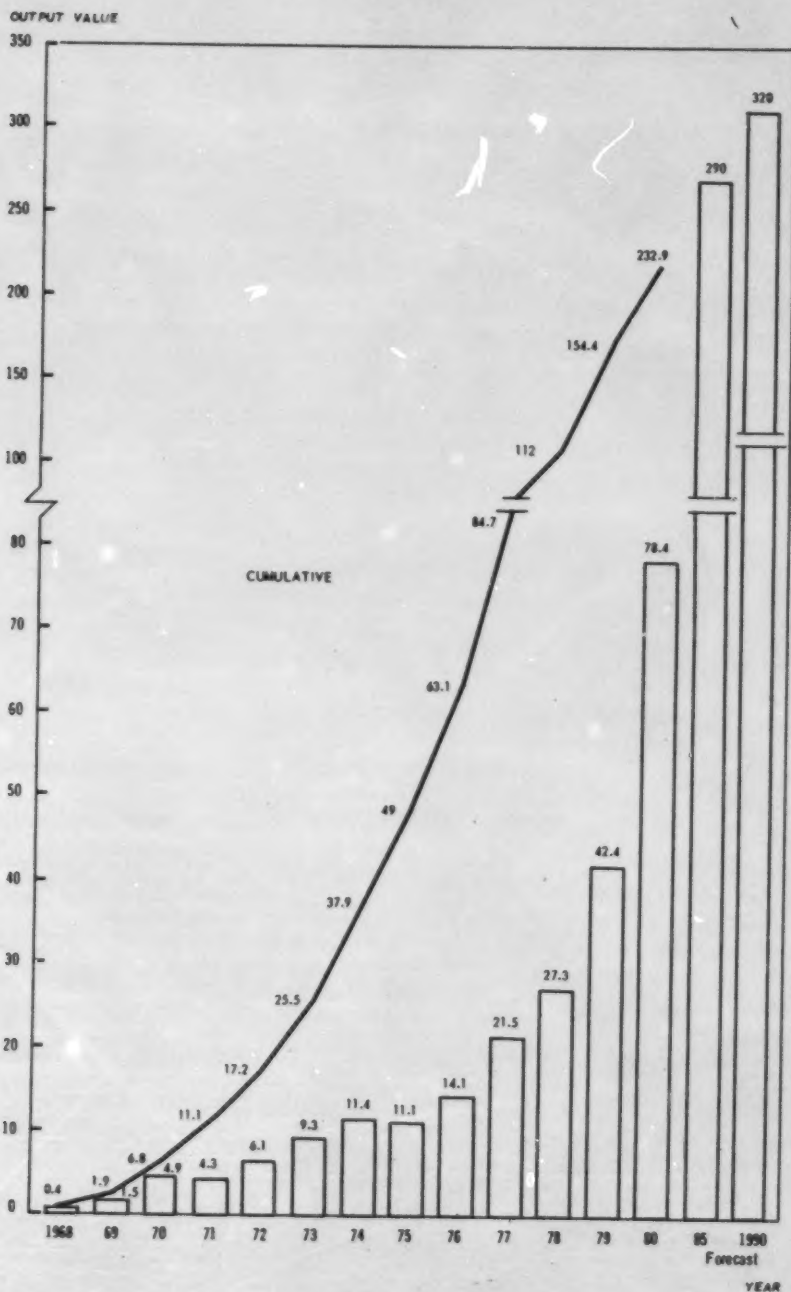
It is believed, as a result, that industrial robots will make an outstanding contribution to the growth of productivity, the stabilization of prices, humanisation of working life, and the development of new industries.

PRODUCTION OF ROBOTS BY NUMBER (1 000 sets)

NUMBER OF PRODUCT (SET)



PRODUCTION OF ROBOTS BY VALUE (1 billion yen)



QUALITATIVE CLASSIFICATION OF ROBOTS

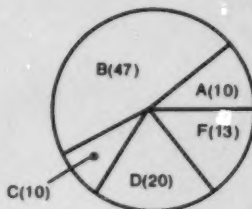
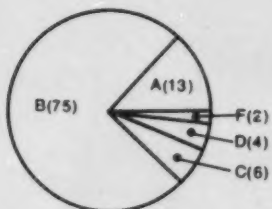
A : Manual manipulators
B : Fixed sequence control robots
C : Variable sequence control robots

D : Playback robots
E : NC robots
F : Intelligent robots

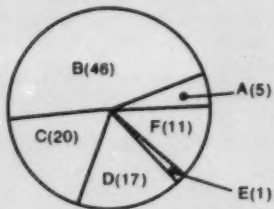
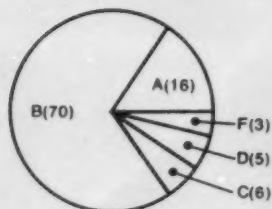
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Value (%)

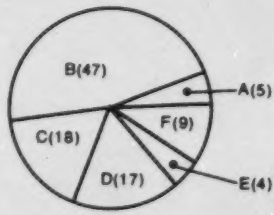
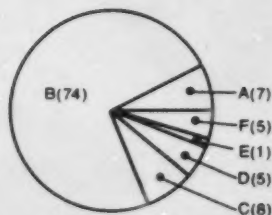
1977



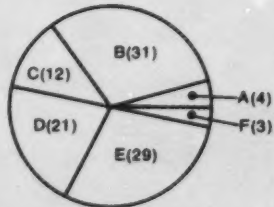
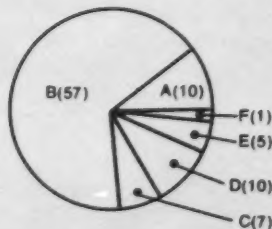
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CLASSIFICATION BY INPUT INFORMATION AND TEACHING METHOD

1. Manual manipulator

A manipulator that is directly operated by a man.

2. Sequence robot

A manipulator, the working step of which operates sequentially in compliance with preset procedures, conditions and positions.

2-1. Fixed sequence robot

A sequence robot as defined above, for which the present information cannot be easily changed.

2-2. Variable sequence robot

A sequence robot as defined above, for which the preset information can be easily changed.

3. Playback robot

A manipulator that can repeat any operation after being instructed by a man.

4. Numerically controlled robot

A manipulator that can execute the commanded operation in compliance with the numerically loaded working information on e.g. position, sequence and conditions.

5. Intelligent robot

A robot that can determine its own actions through its sensing and cognitive abilities.

CLASSIFICATION BY MOTION

1. Cylindrical co-ordinate robot

A manipulator which moves primarily in the cylindrical co-ordinate system.

2. Polar co-ordinate robot

A manipulator which moves primarily in the polar co-ordinate system.

3. Cartesian co-ordinate robot

A manipulator which moves primarily in the cartesian co-ordinate system.

4. Articulated robot

A manipulator which consists primarily of an articulated arm, that is, revolute joints.

NOTE

Manipulator:

A device for handling objects as desired. Without touching with the hands and it has more than two of the motional capabilities such as revolution, out-in, up-down, right-left travelling, swinging or bending, so that it can spatially transport an object by holding, adhering to, and so on.

Robot:

A robot is defined as a mechanical system which has flexible motion functions analogous to the motion functions of living organisms or combines such motion functions with intelligent functions, and which acts in response to the human will. In this context, intelligent functions means the ability to perform at least one of the following: Judgement, recognition, adaptation or learning.

D. ROBOTICS AN INDUSTRIAL CHALLENGE

by

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1. INTRODUCTION

The world's production systems are going through a process of change which is now affecting or will affect the economies of many countries, including France, in three ways:

- widening application of automation to repetitive operations;
- faster replacement, in production systems, special-purpose, inflexible "blind" machines by flexible machine systems;
- a change in the scale of the relevant social problems (employment, work duration).

Rethinking the production system overall means there is an urgent need for a new industrial strategy that will bring the process of technological change under control.

1.1. This means that mastery of robotics becomes a top industrial priority on every score - its role as a productive force, its ability to monitor large-scale manufacturing and distribution channels (for goods and services), the existence of big captive markets at home and abroad, and lastly its impact on work organisation and employment structures.

In this paper, robotics means all the research, production, dissemination, utilisation and training activities (and the links between them) whose development is related to the new automated production methods.

Used broadly, robotics covers the complete machine system consisting of a number of units such as numerically-controlled machine tools, robots themselves, loading/unloading units, tool management and inspection devices, and product quality control devices, all with built-in computerised functions. The entire system is under the more or less central management of a real-time system.

Robotics also includes the tools for designing products manufactured by these systems (computer-assisted design and drawing, machine-tool software generation, etc.).

As the necessary but not sufficient condition for computer-assisted manufacturing, the industrial robot becomes the key to much of the future of automated production, the instrument with which it becomes possible to "generate" a new branch of production.

1.2. In the arc-lights of the media, the introduction and increasing use of robots in the production of goods and services is becoming one of the vectors of the major technological shift under way at international level and affecting the United States, Japan and most of the European economies.

With the help of a research effort that is already substantial though varying widely from country to country, robot design and production is central to certain major industrial projects and developments; several sectors (cars, electronics, aerospace, etc.) are already using robots for production and others where work has to be done in hostile environments (nuclear, underwater, space) will soon join their number. Other research now under way clearly suggests that in yet other sectors there will soon be more service and manufacture (agrofoods).

Hence the need to study the economic and social problems and effects of the change to robots which may be summarised as:

- technology independence or dependence? The answer here requires an analysis of the state of current strengths in robotics;
- the priority of employment, with its two facets - job creation and managing the social effects of technological progress.

2. THE STATE OF INTERNATIONAL COMPETITION

The following date list of events in robotics between 1960 and 1980 precedes an assessment of international competitive strengths in robotics.

2.1. Datelist showing the spread of robotics.

- 1962 The first robot-operated forging process, installed by Unimation, the leading American and world company.
- 1968 The first important robot technology agreement signed between Unimation and Kawasaki, the largest Japanese manufacturer.

1970 In Japan, a national robotics strategy initiated by the MITI (The Japanese Industrial Robot Association was founded in 1971). Robots introduced in Sweden. In the United States the first robot spot-welding line inaugurated by General Motors in its Lordstown Plant, its sudden installation leading to the first large-scale anti-robot dispute (1972).

1974 In France, robots introduced by the Renault Automation Directorate a pilot project (Spartacus) launched under the Ministry of Industry.

1977 Robot-operated spot-welding lines introduced by most big motor manufacturers (in the United States, Japan, and Europe) mainly using the "Unimate" type of unit. Foundation of the French Industrial Robotics Association (AFRI)(1) and the British Robot Association.

1979 The ICAM Programme launched in the United States with the participation of four leading aerospace manufacturers, one machine tool and robot manufacturer (Cincinnati Milacron), and a number of software houses.

1980 Strong development of pattern recognition research.

Growth in the design and production of assembly robots (PUMA, SCARA).

Agreement signed by Kawasaki to supply more than 700 robots to Toyota (1980-1983).

In France, the national Advanced Automation and Robotics Programme launched (1980-1984).

1981 Flexible spot welding plant introduced by Renault at Douai.

Large-scale international moves to establish links (especially between Unimation, Kawasaki and A.S.E.A.).

The Tokyo robot exhibition which showed evidence of a substantial increase in robot production capacity (in particular, construction of the Fuji factory by Fujitsu Fanuc).

1. Leading members (research centres and robot constructors) are listed in the Annex.

1982 In Japan, MITI expected to launch a national advanced robotics project.

In the United States, new major manufacturers expected to enter the market(2).

It is clear from this summary that:

- robotics was slow to get under way;
- the process has very recently been accelerating, and growth will increasingly merit the description "explosive";
- big differences are already forming internationally in the production of robots and in how widely they are used.

2.2. The recent acceleration in the introduction of robots

Whichever economy we consider, and although the statistics are still impaired by the lack of precision in defining robots, it is easy to show that the introduction of robots is growing at a sustained pace.

In the United States (Table 1), three features typify the process:

- robotics is growing rapidly, but the rate varies considerably with sector of activity (electrical engineering, automobile industry, etc.);
- it is a largely oligoplistic activity, with Unimation and Cincinnati Milacron predominating;
- where it is concerned with production activity, research is increasingly focused on assembly operations.

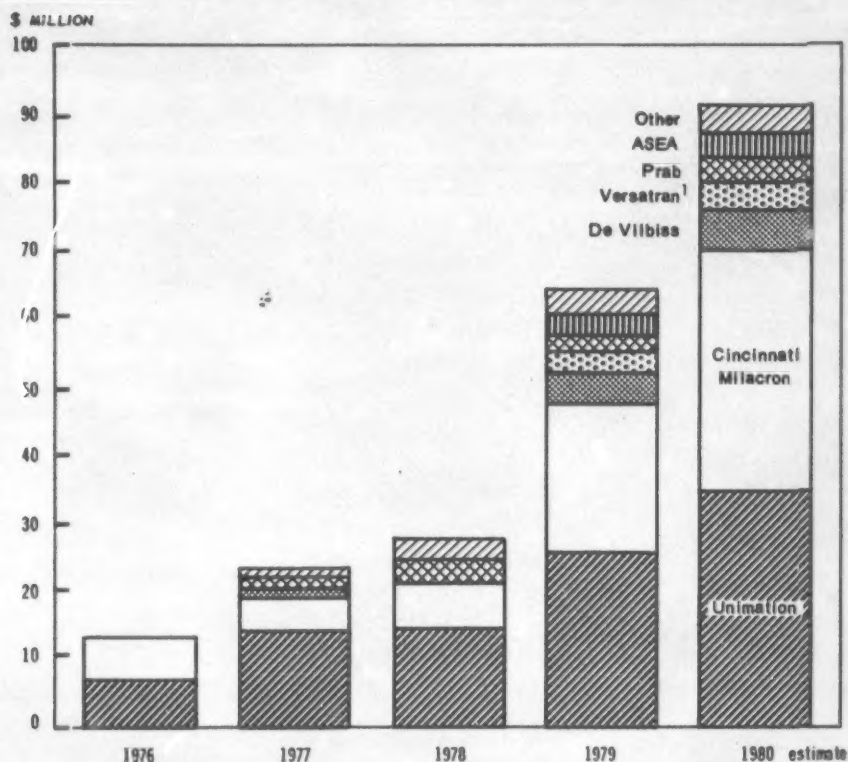
In Japan (Table 2), robotics hits a different pattern for one main reason: the development of industrial robots, for the same reason as the development of other automated machinery and systems, is a priority in the country's industrial strategy the whole aim of which is the systematic improvement of productivity. In particular, many constructors are equipped for medium-run or even long-run production of robots(3).

In Europe, production and distribution capacities vary considerably. Apart from Sweden (Table 3), where

2. See R. Shaffer, "IBM Entry is expected soon in expanding robot industry". Wall Street Journal, 30th October, 1981.

3. At the important robot exhibition in Tokyo in October, 1981, the exhibitors totalled 27 out of the 150 constructors registered with the JIRA.

Table 1
MARKET SHARE OF MAIN UNITED STATES PRODUCERS



1. Acquired by Prab in 1979.

Source: *Business Week*, 9th June, 1980.

robotics activity began in the early 1970s, and to a lesser degree West Germany, the other European economies have only recently begun to develop robotics.

In spite of the wide variations, European countries seem to fall into two distinct groups:

Those that made the decision to phase in the automation of their production facilities even before the 1974 crisis, and were export-oriented. This was the cause for Sweden, and to a lesser extent, Germany.

Table 2

NUMBER OF INSTALLED ROBOTS IN JAPAN (DEFINITION JIRA)

Year	Units (1,000)	Value (billion yen)
1968	0.2	0.4
1969	0.4	1.5
1970	1.7	4.9
1971	1.3	4.3
1972	1.7	6.1
1973	2.5	9.3
1974	4.2	11.4
1975	4.4	11.1
1976	7.2	14.1
1977	8.6	21.6
1978	10.2	29.3
1979	14.5	44.3
1980	19.4	76.9

Source: Robots in the Japanese Economy. Survey Japan 1981 p. 131.

Table 3

NUMBER OF INSTALLED ROBOTS IN SWEDEN

	1970	1973	1977	1979	1984	
Seven largest users	30 (55%)	85 (63%)	310 (63%)	420 (45%)	800 (35%)	
Rest of industry	25 (45%)	50 (37%)	180 (37%)	520 (55%)	1,500 (65%)	
	55	135	490	940	2,300	3,000-9,000

Source: J. Carlsson and H. Selg: The Promotion of Robotics and CAD/CAL in Sweden, OECD Special Session, Paris, 19-21 October 1981.

Those whose decision to develop automation in their production facilities came after and in response to the crisis. Their trading balance in automation machinery is at present in deficit, more specifically imports of industrial robots from the United States and Scandinavia greatly exceed the still tentative exports of their own models. France, the United Kingdom and Italy are in this group, together with Belgium and the Netherlands.

From an international point of view, it seems to be mainly the company backed up by a major industrial group that is in a position to develop a robot production activity on any scale (mainly in the programmable manipulator and increasingly, pattern recognition fields).

United States

Unimation (Condor)
Cincinnati-Milacron
Prab Conveyors
Texas Instruments
General Electric

Japan

Kawasaki
Fanuc Fujitsu
Hitachi
Mitsubishi
Toshiba
Yaskawa
Shin Meiwa

Italy

Comau (Fiat)
Olivetti

France

Renault
AOIP-Kremlin robotique
La Calhène

Sweden

ASEA
Electrolux

Germany

Volkswagen
Kuka
Siemens

Norway

Trallfa

Robot innovation cannot tolerate short-term profitability constraints and therefore requires long-term support before it can successfully secure a foothold in a highly competitive market. From this standpoint the dimension of the company is crucial, since this determines its research potential and budget, production capacity and ability to respond to the market. Most of the major groups are engaged in developing their robot manufacturing facilities(4) and already aim at batch production.

Furthermore, most governments are supporting broad R & D programmes, relieving the industrial groups of this task in the advanced research fields (examples are the NASA-led IPAD programme and the United States Air Force ICAM programme in the United States; the national laser-based flexible workshop programme (1977-1983) and, probably from 1982, the national advanced robot programme in Japan; the Mekoflex programme in the Scandinavian countries, etc.).

In France, the Groupement Automatisation et Robotique Avancées (ARA) set up in 1980 represents a nationwide research activity in this field, as can be seen from the 10 agencies participating: The National Automated Production Development Agency (ADEPA), the Engineering Industries Technical Research Centre (CERIM), the National Space Research Centre (CNES), the Atomic Energy Commission (CEA), the French Petroleum Institute (IFP), the National Computer and Automation Research Institute (INIRA), the National Aerospace Research and Development Bureau (ONERA-CERT), the Renault organisation (RNUR), and Télémécanique.

The ARA project is a four year programme (1980-84) and has three subject areas:

- 1) general robotics;
- 2) engineering and technology;
- 3) advanced remote operation;
- 4) flexible production systems.

The latter depends in particular on broad-based co-operation involving the CNRS, CERT, ADEPA, Renault and Télémécanique.

There is no doubt that the planned strategy (large scale intercommunication) between research and industry, substantial financial resources, prospective impact of wide use in industry) has all the hallmarks of a front-rank industrial priority.

2.3. Technological dependence or independence

An assessment of robotisation strategies at the world level shows considerable differences in numbers of robots installed.

Early in 1981, the British Robot Association published the results of a robot distribution survey which showed that the world stock of programmable robots amounted to some 15,000, or twice the 1978 figure. Of these 40 per cent were installed in Japan (6,000), 25 per cent in the United States and 35 per cent in Europe, Sweden leading (1,200) followed by Germany

(1,130), Italy (400), the United Kingdom (nearly 400), France, Finland (about 200) and the rest (about 300). Robots in the socialist countries are thought to total about 500.

This leads to widely differing rankings for the international production and utilisation of robots as capital goods. In particular, countries which have developed production strengths to the most "effective" degree (Japan, United States and to a lesser extent Sweden) are imposing an 'external constraint' on other economies (Germany, Italy, United Kingdom, France and other European countries) whose most evident symptom is the trading balance deficit. Central to the production and distribution of robots are innovation control strategies. Though American corporations long had the monopoly of technological leadership in robotics, they have been under heavy competition from Japanese companies for about the last five years; this shared leadership indicates that the knowhow in foreign licences has been rapidly assimilated and then outdistanced through R & D. A process of technology transfer in the direction of Europe is under way, mainly through Germany. The diagram below shows that a real process of diffusion is at work, forming a hierarchical pattern of technological domination.

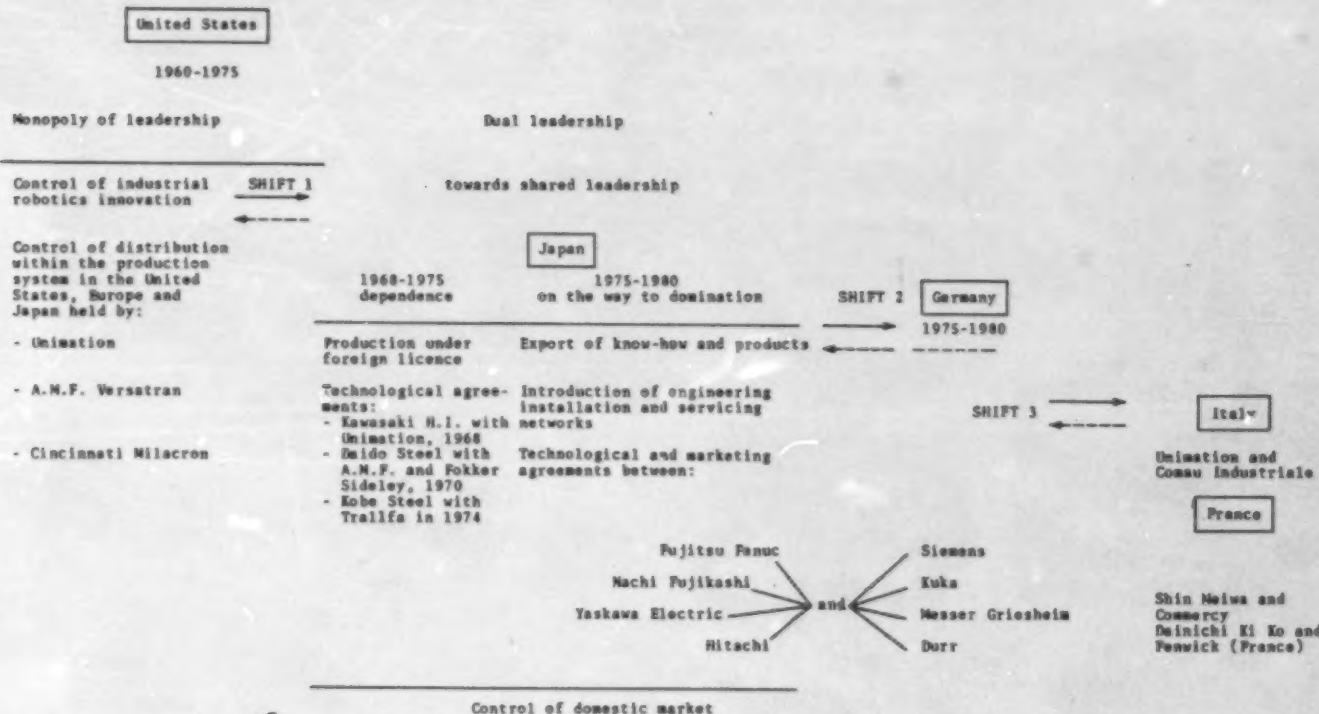
This international trading structure in new robot production systems is an important development. Obviously, an economy importing its capital goods is liable to become permanently dependent on other countries and as a result, lose control of rapidly changing production processes.

From this standpoint, the strength of robotics in France, despite the domestic market's relatively high permeability to foreign capital goods, is grounded upon a dense and resourceful combination of research activities (e.g. the regional development poles of Toulouse, Montpellier, Grenoble, etc.), partly co-ordinated and supported by the national ARA programme. Furthermore, companies supported by national or multinational groups (such as Renault, Kremlin, Leroy Somer...) are standing up well to keen foreign competition.

Control over the domestic market becomes an important factor when employment is a recognised priority: "employment must no longer be regarded as an effect but as a goal, and information technology policy must be formulated accordingly. It is therefore essential to be in control of the process of production and the

¹. The number of robots installed in France is underestimated here. In early 1981, there were 500."

DIFFUSION PROCESS AND EMERGENCE OF A HIERARCHICAL PATTERN OF ECONOMIC DOMINATION(1)



1. Joël Le Quément, "Les robots, enjeux économiques et sociaux. La Documentation française, 1981, p. 154.

utilisation of technologies"(5). There is a way to develop robotics that promotes employment.

3. THE EMPLOYMENT PRIORITY

In the development of robotics there is a whole range of potential new jobs, mainly highly qualified (research, engineers) or at least skilled (technicians, specialised workers). The jobs fields concerned are research, design, production, marketing, training and utilisation. In contrast to this skill-promoting process, the effect of robotisation upon repetitive, unskilled jobs is to displace a growing number of production workers (mainly semi-skilled) with, in most cases, no immediate alternative for them and consequently, greater risks of unemployment. In the long term, using robots for repetitive work will increase the number of deskilled workers.

3.1. Employment trends

It is possible to make a general assessment of the effects on employment of the current wave of robot applications (primary effects) and the forthcoming use of cheaper robots and second generation assembly robots (secondary effects). Production facilities currently using robots or in the process of introducing them show a complex shift in the pattern of employment including both job creation and deskilling (see following diagram).

At the present stage, the primary effects of introducing robots have been to disturb the balance of employment as unskilled workers are gradually displaced from repetitive production jobs while at the same time relatively fewer skilled jobs are created; this especially applies if import flows of such machinery build up.

In the medium term, the secondary effects of introducing robots are liable to take on a more structural aspect, primarily because of the concentration of job creation in multinational producers and the dominance effects induced in the production and servicing of automated manufacturing systems.

5. Mr. Pierre Dreyfus, Minister of Industry addressing the OECD Conference on Information Technologies, Productivity and Employment, 19th to 21st October, 1981.

EMPLOYMENT EFFECT OF INTRODUCING ROBOTS*

	JOBS CREATED		DESKILLING EFFECT	
	Jobs in industrial robot research, design and production	Jobs in servicing and supervising automated machinery, product inspection and marketing	Unskilled repetitive, monotonous tasks	Managerial supervisory, some semi-skilled jobs
Level of qualification	Researchers, engineers, technicians, specialised workers	Technicians, specialists and clerical workers	Unskilled and semi-skilled workers	Supervisory staff
Primary effects				
Workforce trends (absolute figures)	(Automated machinery produced domestically imported)			
Workforce trends, (relative)	Greater risk of a negative balance			
Secondary effects	Risk of jobs being concentrated in multi-national groups producing industrial robots (predominantly American and Japanese and to a lesser degree European)	Development accompanied by of marketing activities		Towards extension of deskilling effect to other types of job in product assembly
		Within user centres		
		Within producers/users of industrial robot type automated machinery		

* J. Le Quément, op. cit., idem, p. 192.

The long-term effects of robots on employment have already been discussed in prospective research. In the United States, Delphi projections(6) suggest that:

as from 1980, a change in the skills structure increasingly oriented towards tasks associated with the design, production and servicing of automated equipment;
by 1985, 20 per cent of the manpower currently employed in assembly operations in the automobile sector will be replaced by automated systems;
by 1987, 20 per cent of all jobs in industry will have had their content profoundly altered, 15 per cent of assembly systems will have been robotised;
in 1988, 50 per cent of the manpower involved in assembling small components will have been replaced.

Another study, by the Stanford Research Institute(7), shows that automation and the introduction of robots will certainly make sweeping changes to handling, assembly and checking operations; nearly 80 per cent of manual tasks will be automated within a generation, i.e. between now and the year 2000, a reduction of about 20 million manual jobs out of the present figure of 25 million. This could well mean that some of the production activities that have been transferred to Third World countries will be repatriated.

In France, a forecasting study(8) anticipates that some 200,000 jobs will be eliminated between now and 1985, a quarter of them due to the introduction of robots.

The functioning of robot production systems can be expected gradually to escape from the constraints of direct labour. On the other hand, indirect forms of labour are likely to grow.

3.2. Robotics as a creator of jobs

It is important to plan for and to preserve, in the same location, the continuity of activities (and

6. Ralph Orr, "4-Day Week, Robot Help are Forecast for 1990. In Europe, the Future has already started" Detroit, Free Press, 8th July, 1978.

7. Palk Laffoon IV "Robots in Factories by Next Generation, Expert Tells U.A.W.", Detroit, Free Press, 29th March, 1979.

8. O. Pastré; J. Tolédano, "Automisation et emploi : l'hétérogénéité des conséquences sociales du progrès technique" in Emploi et système productif, Coll. Economie et Planification. La documentation française, 1979. pp. 161-195.

therefore of jobs) at all levels of robotics. There must be no risk of it becoming fragmented and, as a result of excessive imports, a whole sector of jobs being lost in the areas of robot research, design and production.

It is still difficult to compile a list of the employment spin-off of robot research, design and production but such a list would without doubt show that the opportunities are there to create jobs and especially skilled jobs, for a great many people.

The point is crucial especially if we recognise the growing shortfall in direct jobs as between deskilled workers and the numbers employed in servicing and supervising the new production systems.

To summarise, the trend towards greater independence and flexibility in repetitive production processes entails the break-up of traditional employment structures with, outside the supervision and servicing jobs, growth in indirect, highly qualified types of job. It is also bound to require a reorganisation of working time, partly through the reappraisal of the pattern of the working day (including the night shift).

In concrete terms, the capacity to create jobs depends closely on the condition of the balance of trade in robot systems. In most European countries this balance is in deficit, making it more difficult to reduce the unemployment effects on deskilled workers.

3.3. Management of the social effects of technological progress

The conflictual nature of the introduction of robots is due to the change in the person doing the job: it is still unusual for the deskilled worker to be put into the new job. Consequently, social management of the changeover implies that causes for such workers being made redundant have to be neutralised. Thus new forms of individual and collective protection would need to be negotiated at two levels, work (occupational training, guaranteed redeployment etc.) and income (wage compensation).

By increasing time machine-utilisation the introduction of robots will make it possible to provide wage compensation, to reduce worker intervention time and thus, to facilitate job sharing.

It is certain at the beginning of the 1980s that robots will be applied to repetitive production processes. This shift in a substantial proportion of the production system, especially general engineering,

has already developed to international dimensions in the United States, Japan and Europe.

It is very clear that developing scientific and technological co-operation in so strategic a field can prepare a better basis for reconciling interests resolving the many economic and social difficulties.

Annex

LIST OF MAIN FRENCH ROBOT CONSTRUCTORS(1)

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- ACMA CRIBIER, 3-15 rue Denis Papin, 95250 BEAUCHAMP
- AFMA, 26bis avenue de Paris, 95230
SOISSY-sous-MONTMORENCY
- A.O.I.P. Kremlin Robotique, 6 rue Maryse Bastié, 91000
EVRY
- CERCI, 56 rue Salendro, 94126 FONTENAY-sous-BOIS CEDEX
- Climax France, 15 rue du Pressoir Blanc, 41000 BLOIS
- CSEE, 17 Place Etienne Pernet, 75378 PARIS CEDEX 15
- La Clahene, 5 rue Emile Zola, 95870 BEZONZ
- SCEMI, 61 rue de Funas, 38300 BOURGOIN JALLIEU
- SCIAKY, 119 quai Jules Guesde, 94100 VITRY-sur-SEINE
- Sormel, rue Becquerel, 25009 BESANCON CEDEX
- Soudure Electrique Languepin, 6 rue Prudhon,
932100 LA PLAINE-SAINT-DENIS

LIST OF MAIN ROBOTICS RESEARCH CENTRES

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- CAL - USTL, BP 36, 59640 VILLENEUVE D'ASQ
- CEA - STEP, BP 2, 91190 GIF-sur-YVETTE
- CERT, BP 4025, 31055 TOULOUSE CEDEX
- CETIM, 10 rue Barrouin, 42029 SAINT-ETIENNE CEDEX
- CNES, 16 avenue Edouard Belin, 31055 TOULOUSE CEDEX
- CRAN, C.O. 140, 54037 NANCY CEDEX
- CREATI, BP 637, 59656 VILLENEUVE D'ASQ CEDEX
- ESE, BP 20, 35510 RENNES
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- IMAG, BP 53, 38041 GRENOBLE CEDEX
- INRIA, BP 105, 78150 LE CHESNAY
- INSA, BP 14A, 35031 RENNES CEDEX
- INSA, 20 avenue Albert Einstein, 69621 VILLEURBANNE
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- LAB - ENSCM, 25030 BESANCON CEDEX
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1. Source: A.F.R.I.

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- LETI, Centre de tri 85X, 38041 GRENOBLE CEDEX
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